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COMPUTER MODELLING FOR THE OPERATION

OF A MARINE TERMINAL

BY

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SUMMARY

A fixed time-step model was used to simulate the operation of a marine terminal. Events in the model were generated by Monte Carlo Technique using a simple normal distribution. The result of the simulation led to a financial appraisal of possible future unloading equipment.

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CHAPTER I

INTRODUCTION

The Hongkong Electric Company Limited (HEC) is one of the two utility companies supplying electricity to the territory of Hong Kong. It has two power generating stations located at Apleichau and Lamma Island. The Apleichau Power Station is an oil fired station which will be phased out for redevelopment in the near future. The Lamma Power Station is a developing dual coal/oil fired station, having a total planned capacity of 1800 Megawatts (MW). The existing plant consists of two 250 MW units, two 125MW units and two 350 MW units. There is a plan for the installation of one additional 350 MW unit in 1992 and possibly two other units of 350 MW or 500 MW capacity after that depending on the demand.

Steam to drive the turbo-generators is produced in the boilers at high temperature and pressure. The boilers are designed to fire either 100 percent coal, 100 percent oil, or a coal/oil mixture. Under normal operating conditions all units burn 100 percent coal, with oil firing facility for start up and standby. At 1800 MW generating capacity, the estimated coal consumption will be about 3.4 million tonnes annually. Coal supplied to the power station is received at the fuel jetty located at the west end of the station. The jetty has been designed to accommodate sea going vessels of up to 100000 deadweight tonnes.

Coal is supplied to the station by ocean going bulk cargo carriers and received at the fuel jetty by two unloaders each of 750 tonnes per hour cream digging capacity. The coal is either transferred to the coal storage yard , or fed to the boiler bunkers directly via duplicate 2000 tonne per hour conveyors. A stacker of 3000 tonnes per hour capacity has been installed in the coal yard and can form a longitudinal stock pile to a height of about 15 metres. Reclamation of coal is by mobile plant to underground hoppers, from where it is transferred to the conveyors by travelling paddle feeders.

The factors influencing the operation of the coal unloading jetty are primarily the demand for coal at the power station, and the rate at which large bulk carriers can be unloaded, together with a wide range of other effects such as the inherent randomness in vessel arrivals which is superimposed on any predetermined shipping schedule, random fluctuations in power station load factors, disruption due to weather, and unexpected breakdown of unloading equipment.

The power station requires forty to sixty shipments from various suppliers and loading ports. Inevitably there is a degree of randomness or uncertainty associated with a supply of this nature. Some of the causes are:-

- The distances from the loading ports to Lamma are fairly large and voyage time could be up to 45 days. There will be variation in the exact time taken.
- There is the possibility of congestion at the loading ports which will delay loading of HEC consignments.
- The local weather condition at Hong Kong will occasionally disrupt and delay unloading.
- There is the possibility of occasional breakdown at Lamma.

When a vessel does arrive it will present its notice of readiness when ready for berthing and unloading. The freight contract will specify an average rate of unloading which will be set against HEC's performance from this point onwards. In principle if unloading takes longer than the time corresponding to the contract unloading rate, HEC becomes liable to demurrage charges; on the other hand , if unloading is completed earlier than the contract period, HEC can claim a credit for early despatch. If there is congestion at Lamma, i.e. the berth is occupied when the vessel arrives, HEC will still have to accept the notice of readiness and the contract time available for unloading will start to elapse. The contract for coal ships from China did not include this particular item and thus Chinese ships have no demurrage nor despatch.

The requirement for the marine terminal depends on an assessment of the degree to which congestion will occur and the accompanying hazards of a queue of vessels waiting for a berth and the demurrage costs that are being incurred. If the throughput at a marine terminal is going to increase progressively, a point may be reached where these factors require the addition of ship unloading capacity.

The annual coal consumption is directly proportional to the total electricity consumption which is estimated to have 5-6 percent growth per annum. The corresponding increase in coal consumption implies that an increasing amount of coal must be brought in either by increasing the number of shipments per year or increasing the draft of the vessels, or both. The turn around time for unloading each vessel will depend on the reliability and efficiency of the ship unloaders and associated conveyor systems. The present coal unloading jetty configuration of one berth and two grab unloaders is expected to become saturated some time in the future. Therefore, an assessment is required to determine when the third unloader will be required.

CHAPTER II

METHODOLOGY

The inherent randomness associated with the various factors precludes the use of analytical methods and the application of discrete system simulation is preferred. In simulating any dynamic system, whether continuous or discrete, there must be a mechanism for the flow of time. There are two fundamentally different models for moving a system through time: the fixed time-step model and the event to event model. In a fixed time-step model a timer or clock is simulated by the computer. This clock is updated by a fixed time interval and the system is examined to see if any event has taken place during this time interval. All event that take place during this period are treated as if they occurred simultaneously at the tail end of this interval. In a event to event simulation model the computer advances time to the occurrence of the next event. It shifts from event to event . The system state does not change in between. Only those points in time are kept track of when something of interest happens to the system.

In our marine terminal simulation, the time-step model is to be adopted because even though the major events are the arrival of coal ships, there are many other events happening between coal ship arrivals. For example, coal is consumed hour by hour, routine maintenance is carried out on the unloaders between shipments, the occurrence of typhoons etc.. It would be more convenient to use the time-step model since many of these variables change by the hour.

Basically, this is a simulation of a queueing system that can handle one customer (one ship) at a time with two or more servers (two or more unloaders). Factors affecting operation of the terminal include:-

- shipping delays and early arrivals
- despatch and demurrage
- weather condition
- tidal effect
- reliability of unloaders and associated equipment
- coal consumption pattern
- vessel draft
- coal yard storage capacity
- maintenance down time
- cost of additional unloader(s)
- queue discipline

The required randomness for shipping operation, unplanned breakdowns of unloaders, weather condition shall be generated by the computer using Monte Carlo Technique with probability distribution functions taken from historical records.

The programme shall be written in BASIC and run on an IBM personal computer. The results of the simulation shall lead to a financial appraisal of the third unloader to compare the capital investment at different point in time with the probable saving in demurrage costs.

CHAPTER III

MODEL BUILDING

The loading of a power utility marine terminal is directly proportional to the coal consumption. With the steady growth in electricity demand, there will be a corresponding increase in coal consumed per year. A forecast of future coal consumption up to the year 1996 is shown in Table 1. In the input segment of the programmes, annual coal consumption is broken down into weekly consumption ratios corresponding to the seasonal variation and stored as READ DATA elements. Daily consumption figures are generated from weekly ratios to conform to the variation of consumption within the week.

About half of the coal consumption is currently supplied from China under a contract which will expire by the year 1992. The vessels used is of the 52000 dead weight tonnes (DWT) category because of port facility limitation in China. The contract did not include any demurrage/despatch clause. Other sources include Australia, Canada, South Africa and also from the spot market using 65000 DWT category vessels . Contracts for these sources stipulate a contract unloading rate of 15000 tonnes per day, unloading start time being counted 12 hours from the receipt of Notice of Readiness, NOR. The lay time, which is the contract time allowed for unloading one shipment, is given by the following equation,

Lay time = (vessel DWT/15000) x 24 + 12 hours

If unloading is completed in a time shorter than the lay time, then the ship company will pay HEC a despatch at the rate of US$3750 per day. However, if the unloading is completed in a time longer than the lay time, HEC will have to paid the ship company a demurrage at the rate of US$7500 per day. The actual unloading time is always counted from the time of NOR.

Because of this difference in the contracts on despatch and demurrage, preference is always given to non Chinese ships when there are more than one ship waiting, i.e. the programme need to provide for queue jumping.

At the beginning of the year, a coal supply plan is drawn up so that coal shipments could match coal consumption pattern as far as possible. The basic rule for scheduling deliveries is to keep a minimum stock level of 200000 tonnes and 280000 tonnes in the winter months and summer months respectively. However, the actual arrival dates almost always deviate from the planned arrival dates because of many reasons. For this simulation, to simplify the model, assumption is made that deviations are due to arrangement on HEC side only, i.e. a vessel could tender NOR as soon as it arrives local waters.

Due to limited available statistics from other sources, deviation of actual arrival dates from the planned arrival dates for Chinese coal ships were compared. The results are shown in Table 2. For all practical purposes, the distribution could be approximated to a normal distribution. Because of the small amount of historical data for other sources, it is not practical to use the same method to confirm the distribution. Therefore, an assumption is made to use the normal distribution for other sources as well.

To generate samples from the normal distribution, the sampling method is used. This is a subprogram named GAUSS available on IBM programme library. The equivalent BASIC segment is shown below,

```
SUB GAUSS (S,AMEAN,V) STATIC
A = 0
FOR I1 = 1 TO 12
RANDOMIZE TIMER
R = RND
A = A + R
NEXT I1
```

```
V = (A-6.0)*S + AMEAN
END SUB
```

where

S = standard deviation

AMEAN = mean

V = returned variate

The sampling procedure functions by obtaining twelve uniformly distributed variates, compute their sum and then subtract six. The output from this sampling procedure are sample sums that are normally distributed with a mean of zero and a standard deviation of one. These output characteristics are same as the Z statistics of the standard normal distribution. When the outputs from the sampling procedure are adjusted for the required mean and standard deviation, the variates are appropriate for use in simulation studies.

Since each source of coal has its own statistics, the input of coal shipments to the programme is done on a source by source basis. Five sources are built in to the programme as follows,

Source number	Source Name
1	China
2	Australia
3	Canada
4	South Africa
5	Spot

It is envisaged that no more Canadian coal will be purchased in the future because of the poor quality.

Actual arrival dates are generated from the planned dates using the subprogram GAUSS. Arrival hours are generated using a uniform distribution. The shipments are then arranged in a number schedule according to the order of arrival.

Another factor affecting ships coming in for the berthing operation is the tide. The location of the jetty in relation to the West Lamma Channel and the dredged approach requires that ships should be towed to the jetty against the current. This requirement dictates that approach of ships will be made in the hours between flood tide and an hour after ebb tide. The Royal Observatory Almanac for 1988 published by the Hong Kong Royal Observatory was consulted, and hour by hour tide data was stored in a file called tidedata.dat. The same tide data is to be used for all the years on the assumption that tide patterns do not change much due to the consistent movement of the heavenly bodies, i.e. the moon and the earth.

In addition to the tides, due to obvious safety reasons and the availability of tugs, all berthing and unberthing operations must be done in day light.

In Hong Kong, typhoons in the summer months may interrupt berthing and unloading operations. The general rule is that ships unloading at the jetty must be unberthed and towed out to open sea on the hoisting of number three signal or higher. This is to protect the jetty from damage. The ship will wait in open seas and will return when the number three signal is lowered. The Royal Observatory Almanac contains information on monthly mean number of days with number three or higher Tropical cyclone warning signals. An assumption is made to assign seven as an annual mean number of typhoons with a standard deviation of two. A subroutine is used to generate typhoons such that the monthly and annual typhoon hours approximate the recorded average. Probability of typhoon is assumed to be normally distributed and clustered around the months July, August and September.

The reliability of the unloading facilities on the jetty is also a factor governing how quickly a ship could be unloaded. The major cause of unloader break down is wire rope failures. Wire rope life depends on the number of running hours of the machine, i.e. the number of cycles of wear and fatigue to the strands took place when the wire rope flexed over pulleys. Table 3 listed some statistics for the life of these wire ropes. Again, the probability of failure could be approximated by a normal distribution. When a failure has occurred, the unloader has to be taken out of operation and repaired as soon as possible. From experience, the time to repair is approximately ten hours. To improve the reliability of these equipment, the unloaders are inspected after each shipment and the wire rope would be replaced if found to be defective, provided that there is sufficient time to do so before the next ship arrives.

A diagrammatic system overview is shown in Figure 1, each building block will be discussed in detail in the next Chapter on Programming.

CHAPTER IV

PROGRAMMING

The programme is basically divided into two major segments and a number of subroutines to facilitate programming.

The first segment is the input segment which controls the input of data files and the generation of typhoon, coal consumption and ship arrival schedules. The second segment is the main body of the programme which handles the queueing and unloading of ships.

For the first segment, i.e. the input segment (Chart no. 1), provision must be made to pass variables to the second segment for execution. This is achieved by the use of the COMMON statement. Array variables are dimensioned into static and dynamic arrays carefully in view of the limited memory working space available in a personal computer. Subroutine INDATA (Chart no. 2) then open the data file for input. Tide information input is also handled by this subroutine. Favorable tide conditions for ship approach are marked up in a 365 day 24 hour calendar for the use of the main segment.

Subroutine TYPHOON (Chart no. 3) generates the number of typhoons in the year and then determines the start time and duration for each typhoon. The hours in which typhoons will occur are then marked up in a calendar. Subroutine COALCON (Chart no. 4) generates coal consumption on a week by week basis. For each week, since the demand of electricity and hence coal consumption on Saturday and Sunday are less than those for the week days, Coal consumption ratios for the weekend are generated separately. For the weekdays, some randomness is also built in to simulate the day to day load fluctuations. Coal consumption figures are used to check the rise and fall of stock level and will become useful in the analysis for the building of coal silos as storage in the future.

The input segment then goes on to generate the actual arrival days and hours for each coal delivery and then put them into a number schedule according to the order of arrival. The schedule numbers are then put into a calendar and passed onto the second segment for processing. A provision is made to print the input data for reference using the subroutine DINPUT.

The second segment, which is the main programme (Chart no. 5), also has to begin with defining all the common variables using the COMMON statement in order to retain the variables it required. It then has to dimension variables unique to this segment. The subroutine INITUNLOADER (Chart no. 6) then initializes running hour, time to failure, and time to repair for each ship unloader one by one. Up to this point, all the environmental and physical variables are residing in the memory and the simulation can begin. The queueing is done by moving the clock time forward hour by hour 24 hours a day, 365 days a year. In each hour, the programme checks for ship arrivals. If there is an arrival, the programme then calculates the time of submitting the Notice of Readiness, NOR. This time is important because it affects the payment of demurrage or receipt of despatch.

Subroutine ASSIGNNOR (Chart no. 7) ensures that NOR is only tendered between 0800 hours and 1600 hours daily when the jetty office is manned, and also no typhoon signal is hoisted. The in coming ship is then put into the queue. If the in coming ship is a Chinese ship, then it will simply join the end of the queue. If the in coming ship is a non-Chinese ship, then it will be put behind the last non-chinese ship in the queue but in front of all other Chinese ships already queued up. This is done by a series of IF-THEN-ELSEIF statements in the subroutine ARRQUEUE (Chart no. 8). The subroutine

ARRQUEUE provides for a queue of up to 6 ships at a time. The maximum queue size is only limited by the BASIC software's ability to handle large array elements. In this programme, there are quite a number of large arrays with 365 x 24 elements each. Therefore, unless it is absolutely necessary, it would be wise to keep the queue size down. However, in the future, if the need arises, the queue size could be extended.

Having settled the incoming ship, if any, into the queue, the programme then checks if there is any ship in the queue. If there is no ship in the queue, then the programme moves on to the next hour or the next day depending on whether it has moved passed 2400 hours or not. If there is a ship in the queue, then it will check if the jetty is occupied by another ship. If the jetty is occupied, then ships in the queue have to wait and the programme moves to the next hour. If the jetty is vacant, then the programme assign the first ship in the queue to berth and re-arrange the ships in the queue, i.e. each ship in the queue will move up one position.

The committed ship will go into the subroutine UNLOAD (Chart no. 9 and 10) to start the berthing sequence and to commence unloading coal when tied up. If the NOR has not already been submitted, then the ship has to wait until NOR is accepted by the jetty officials. If the ship comes in late in the year on the last day, then there is no possibility of unloading it in the year and an arbitrary NOR day/time of 365/24 is assigned to mark the event.

When NOR has been accepted, the ship can proceed to the jetty for berthing. Pilot boats and tugs have to be used to guide and manoeuvre the ship from local Hong Kong waters to the jetty. This has to be done in day light between 0600 hours and 1800 hours and under the right tide condition. Typhoon interruptions have complicated the programming somewhat. As soon as a typhoon situation has developed, depending on which stage of the unloading the ship is undergoing, it must stop unloading and make preparation to move out to local waters and then to open seas to seek shelter. If all is well and the ship is along side the jetty, then the shore crew will assist in tying up the ship to the jetty and start unloading.

Chart no. 10 begins with a subroutine within the subroutine. The subroutine BREAKDOWN (Chart no. 11) compares the current running hour of each unloader with the respective time to failure to ascertain if a breakdown has occurred. If the current running hour is greater than or equal to the time to failure, then the unloader has failed and it must be taken out of service and repaired by an emergency crew. This breakdown is represented by returning a zero value for the unloader capacity for that hour. The time to repair is then used to mark in the calendar all those hours in the future in which the unloader is under repair and is not available. Replacement of unloader wire rope is effected by resetting the running hours of that unloader to zero and generating new times to repair and failure.

The unloader capacities returned from the subroutine BREAKDOWN are then subjected to further modification. When the cargo holds have just been opened, the coal is up to the main deck level. It is easier for the unloader operator to position the grab over the coal and hence the machine cycle time is shorter and cream digging rate can be maintained. However, as the level of coal goes down, the grab has to sink deeper and sometimes has to be swung to dislodge coal hanging up on the side wall. This slows down the operation considerably and it is estimated that this occurs between the unloading of 0.3 to 0.7 of the cargo in the hold. In this case, the unloader rating is downrated to 0.7 of cream digging rate. Towards the end of the operation when cleaning up of the hold is being carried out, the unloading rate will be degraded further to 0.4 of cream digging rate.

After the total available unloading capacity has been determined, the subroutine checks if there is sufficient coal left in the hold for unloading. If there is enough coal to occupy the unloader for the hour, then the subroutine goes on to the next cycle of unloading. If the coal left is less than the unloading capacity in the hour, signifying that unloading has completed. Then the subroutine registers this completion time for the purpose of demurrage/despatch calculation. It then checks for day light and if alright, unties and releases the ship and returns control to the main queueing programme.

The main queueing programme then calculates berth occupancy using subroutine BERTHOCC. This is the time between committing the ship to berth and releasing it. The subroutine QUEUETIME then indicates on a calendar those hours that were occupied by this ship to prevent other ships from using the berth at the same time. It also sums up the unloader breakdown hours for reference. A flag is also set in case there is an arrival since the committed time for the next subroutine.

Subroutine INSPECT (Chart no. 12) handles the wire rope inspection after each shipment. The criterion for an inspection is that there must be sufficient time for wire rope changing in case the inspection reveals a defect. If there is a ship waiting to come in or the arrival is due in a very short time, then the inspection is cancelled so as not to delay the berthing of the ship. The general rule is that, if the unloading of the ship is completed before 0800 hours, then inspection can be carried out if the next ship will come in later than 0800 hours the following day. On the other hand, if the unloading finish time is after 0800 hours, then inspection can only be carried out if the next ship will come in later than 0800 hours the day after the following day. In the programme 2000 hours is used because no ship can come in after dark and there is no point to check further into the night. An inspection is accomplished by resetting the running hour to zero and generating new times for failure and repair.

By this time, the programme has completely unloaded one ship. It then sets the clock back to the time when the ship was assigned to berth and continue the queueing loop for the rest of the year.

When all the ships have arrived, and the clock has come to the end of the calendar, subroutine DOUTPUT calculates the day by day change in coal stock levels and the demurrage/despatch for each ship. A printout giving the day by day events for the year and a summary table for the vital statistics are produced in addition to a data file output. An example of such a printout is shown in Appendix 2 together with the input printouts. Appendix 1 gives the listing of the programme. A list of variables used and their descriptions is shown in Appendix 3.

At the end of the programme listing, there are two subprograms for event generation. One of them is GAUSS using a normal distribution. The other is NEGEXP using a negative exponential distribution. NEGEXP is built in to the programme for future addition of variables which may not be conveniently approximated by a normal distribution.

CHAPTER V

PROGRAMME IMPLEMENTATION

In the design and evaluation of simulation experiments, the length of simulation runs is important. In our case, each simulation run involves running the programme for a complete cycle of 365 days which involves 8760 time segments. Each run will generate one set of output data for a particular year using a planned shipping schedule and a set of unloader criteria. Our main concern is the net payout of demurrage/despatch at the end of the year. To determine the number of iterations required to generate data which are representative, a simple graphical approach is adopted. The input data for the year 1987 was fed into the computer and the number of iterations set to 3200, i.e. repeating the year 1987 for 3200 times. The results are graphed in figures 1 to 4. By inspection, figure 4 shows that the net payout converges after 1600 runs.

Another approach would be to consider the outcomes of the simulation as a sampling process and then estimate the number of samples required to achieve a certain accuracy. For example, after 3200 iterations, the mean net payout is -US$63637 and the standard deviation is 33263. If we want to be 99% confident that the accuracy will be within 1%, then the following equation can be used to find n, the number of iterations,

$$n = (2.58 \times 33263 / 636)^2$$
$$= 18618$$

The figure 1600 was chosen since this point was on a reasonable level part of the curve.

The value of a despatch of US$63637 for 1987 was compared with the actual figure and was said to be within 10%. The actual figure could not be disclosed due to commercial reasons. The actual value may not be too meaningful because 1987 was an exceptionally good year with virtually no typhoon interruption at all.

Another point worth mentioning is that the average number of typhoon hours in the year generated was 283 hours after 3200 iterations and was within 4% of the Royal Observatory's average of 295 hours.

For the production model, all printouts were suppressed and results were output to data files. A short BASIC programme was written to control the iteration process as well as to input data files to cater for different coal schedules for different years.

There are two major series of input data. One series involves the use of two unloaders and the other series involves the use of three unloaders, the third one being an additional new unloader similar to the existing ones. Each set has two versions, the first version assumes that the Chinese coal contract will continue to leave out the demurrage/despatch clause. The other version assumes that all vessels can incur demurrage and despatch.

Each data set requires approximately 17 to 18 hours run time on an IBM PCAT with 6 MHz 80286 processor augmented by a 80287 Maths Co-processor in order to achieve 1600 iterations. For the first version, 10 data sets from 1987 to 1996 were used for the two unloader series and 8 data sets from 1989 to 1996 were used for the three unloader series. Due to time limitation when running the second version, only 4 data sets from each series , i.e. for the years 1990, 1992, 1994 and 1996, were completed. Subsequently, simulations for two more years, i.e. 1998 and 2000, were run for each condition.

The output files from each data set were loaded into a spreadsheet software for the calculation of mean and standard deviation for each output variable.

CHAPTER VI

RESULTS AND DISCUSSION

The results were tabulated in Tables 4 to 7, and presented as graphs in Figures 6 to 9. Figure 6 shows the net demurrage minus despatch under different scenarios. A positive value on the Y axis indicates a net payment of demurrage whereas a negative value on the Y axis indicates a net income of despatch. It can be seen that if the present contract arrangement with China remains unchanged for the future, HEC will not incur net payment of demurrage before the year 1997, even with a two unloader configuration on the jetty. If three unloaders are used, while keeping the same contract terms, there will be a net income of despatch in the range US$200,000 to US250,000 per year up to the year 2000, which may look very impressive at first sight. However, the cost of a new unloader is likely to be in the order of US$4,000,000. The company's expected return on asset is 13.5% which is regulated by the Government's Scheme of Control. The expected return on US$4 million will be US$540,000 per annum. Without the need of going into discounted cash flow calculations, it is clear that the returns do not justify an investment into buying a new unloader before the year 2000.

The effect of changing the contract terms so that ships from China will also be liable for demurrage or despatch could also be seen on Figure 5. For the Two unloader situation, the change in contract terms increases the chance of incurring demurrage and brings forward the start date for net payment of demurrage from 1997 to 1993. On the contrary, change of contract terms will have an opposite effect for the three unloader situation. An increase in earning is expected. This is probably due to the fact that the higher unloading rate make it possible to reduce waiting time and turn around time.

Apart from the financial aspect of terminal operations, the unloading facilities must be capable of supplying fuel to the station without prolonged interruptions. Table 8 shows the average number of days per year that a stock out situation will occur. It could be seen that the probabilities of a stock out for both unloader configurations are extremely low. Under the worst situation, the company still have its heavy oil reserves to fall back on. Furthermore, the situation can be improved by better coordination of shipping schedules and prompt corrective actions when the stock has been depleted to a certain predetermined level.

Figures 7, 8 and 9 give additional statistics relating to the change in the berth occupancy rates, queue lengths and waiting time per ship.

From the above analysis, we can conclude that if the present contract terms with China remain unchanged, then there will be no requirement for the third unloader before the year 1997. If the contract terms with China will be changed to include demurrage or despatch, then an appraisal should be made in the year 1993 to look into the installation of the third unloader. If the decision is to install the third unloader before 1993 for reasons beyond the scope of this study, then the contract terms with China should be changed to include demurrage and despatch to maximize the income of net despatch so as to take advantage of the increased capacity.

There are provisions in the programme for future development regarding the study of the impact of reduced storage area as a result of future construction work for Unit 7 and Unit 8 beyond 1996 which will inevitably eat up space, and the possible implementation of the coal silo scheme.

It is also possible to test the model for the effect of installing a completely new type of unloader called continuous unloader by varying the unloading capacity and the breakdown rate to cater for the uncertainty inherent with a new generation of machines. Another possible area of study could be in the utilization of mobile equipment in the reclaim process in which double handled coal is reclaimed from the coal yard and fed to the coal bunkers.

Furthermore, additional work may also entail changing the category of vessels used and thus reducing the number of ships required to be unloaded per year. This may have profound effects on the berth occupancy and help to ease the queueing problem.

CHAPTER VII

CONCLUSION

A model for the operation of a marine terminal has been developed. The result of the computer simulation indicates that the existing two unloaders on the jetty could cater for the future work load up to the year 1997 provided that existing contract terms with China regarding despatch and demurrage remain unchanged. Furthermore, the model could be further developed to take into account additional variables which may have important implications on the whole fuel handling system.

TABLE 1
COAL CONSUMPTION FORECAST (METRIC TONNES)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
JAN	134,822	145,700	155,161	165,028	174,759	184,423	195,573	206,453	217,063	229,295
FEB	126,050	130,500	138,974	147,811	156,527	165,183	175,170	184,915	194,418	205,374
MAR	153,047	149,500	159,208	169,332	179,317	189,233	200,674	211,838	222,724	235,275
APR	154,017	158,800	169,112	179,865	190,472	201,004	213,157	225,016	236,580	249,911
MAY	182,521	196,500	209,260	222,566	235,691	248,724	263,762	278,436	292,745	309,241
JUN	196,680	206,000	219,377	233,327	247,085	260,749	276,514	291,897	306,898	324,192
JUL	212,201	226,400	241,101	256,433	271,554	286,570	303,897	320,803	337,290	356,296
AUG	208,218	221,500	235,883	250,883	265,677	280,368	297,320	313,860	329,990	348,585
SEP	198,449	211,100	224,808	239,103	253,203	267,204	283,360	299,124	314,496	332,218
OCT	178,950	189,800	202,125	214,978	227,654	240,243	254,769	268,942	282,763	298,697
NOV	154,845	162,200	172,732	183,716	194,550	205,308	217,721	229,833	241,645	255,262
DEC	150,200	158,000	168,260	178,959	189,512	199,992	212,083	223,882	235,388	248,652
ANNUAL	2,050,000	2,156,000	2,296,000	2,442,000	2,586,000	2,729,000	2,894,000	3,055,000	3,212,000	3,393,000

TABLE 2
DELAY STATISTICS

PLANNED ARRIVAL DAY	ACTUAL ARRIVAL DAY	DELAY
6	19	13
32	46	14
60	57	-3
102	90	-12
121	94	-27
140	156	16
162	160	-2
178	163	-15
192	200	8
213	216	3
240	236	-4
256	241	-15
278	282	4
2	17	15
33	35	2
63	65	2
92	84	-8
119	101	-18
127	126	-1
146	141	-5
165	162	-3
186	185	-1
207	201	-6
216	217	1
237	238	1
259	245	-14
283	273	-10
313	307	-6
339	332	-7

INTERVAL	FREQUENCY
LESS THAN -20	1
-19 TO -10	6
-9 TO 0	11
1 TO 10	7
11 TO 20	4
SUM	29
MEAN	-2.68965
STD DEV	10.04851

TABLE 3
UNLOADER FAILURE STATISTICS

UNLOADER NO. 1 WIRE ROPE HOURS TO FAILURE			UNLOADER NO. 2 WIRE ROPE HOURS TO FAILURE		
92			135		
168	INTERVAL	FREQUENCY	253	INTERVAL	FREQUENCY
100	<= 100	6	89	<=50	3
101	101 TO 150	12	103	51 TO 100	3
100	151 TO 200	10	142	101 TO 150	16
113	201 TO 250	2	107	151 TO 200	7
167	251 TO 300	1	153	201 TO 250	2
159			204	251 TO 300	2
122			135		
138			253		
92			137		
208	MEAN	141.8387	124	MEAN	138.0606
261	STD DEV	42.15110	145	STD DEV	52.44734
176			188		
104			140		
182			130		
150			146		
172			48		
214			136		
127			227		
185			78		
164			172		
120			158		
172			146		
151			48		
135			136		
106			101		
74			126		
91			165		
133			7		
120			172		
			158		
			94		

TABLE 4
Demurrage - Despatch in US$

	no demurrage for Chinese		demurrage for all ships	
	2 unloaders	3 unloaders	2 unloaders	3 unloaders
1987	-63636.72			
1988	-69807.07			
1989	-65398.32	-180333.51		
1990	-64564.35	-188756.02	-60134.77	-324452.62
1991	-62576.46	-203505.29		
1992	-53100.00	-201635.00	-21457.90	-340210.15
1993	-55182.95	-217240.93		
1994	-50780.24	-232467.89	8370.64	-377315.64
1995	-43666.34	-234987.23		
1996	-27480.53	-243839.53	105237.11	-405540.88
1997				
1998	6144.99	-259273.01	188153.04	-354013.27
1999				
2000	48096.97	-279253.70	373427.90	-278035.52

TABLE 5
Berth Occupancy (percentage)

	no demurrage for Chinese		demurrage for all ships	
	2 unloaders	3 unloaders	2 unloaders	3 unloaders
1987	32.46			
1988	33.24			
1989	35.58	24.35		
1990	37.65	25.64	37.96	25.56
1991	40.28	27.48		
1992	41.46	28.15	41.55	28.02
1993	44.88	30.67		
1994	46.80	31.94	46.96	31.90
1995	49.57	33.83		
1996	52.55	35.58	52.30	35.56
1997				
1998	59.15	40.07	59.23	39.88
1999				
2000	66.91	45.07	67.11	45.17

TABLE 6
Queue Length (no. of ships)

	no demurrage for Chinese		demurrage for all ships	
	2 unloaders	3 unloaders	2 unloaders	3 unloaders
1987	1.75			
1988	1.73			
1989	1.86	1.52		
1990	1.96	1.62	2.01	1.70
1991	2.11	1.72		
1992	2.21	1.83	2.23	1.89
1993	2.30	1.95		
1994	2.27	1.91	2.27	2.01
1995	2.53	2.10		
1996	2.60	2.15	2.64	2.12
1997				
1998	3.32	2.50	3.13	2.61
1999				
2000	3.81	2.83	3.87	2.85

TABLE 7
Waiting Time (hours)

	no demurrage for Chinese		demurrage for all ships	
	2 unloaders	3 unloaders	2 unloaders	3 unloaders
1987	14.03			
1988	13.55			
1989	14.94	6.39		
1990	16.65	7.21	16.25	7.50
1991	18.69	7.78		
1992	20.69	8.68	19.67	9.23
1993	22.60	9.62		
1994	22.63	9.49	22.64	10.01
1995	27.05	11.19		
1996	29.28	11.74	28.59	11.07
1997				
1998	43.53	15.68	42.30	15.92
1999				
2000	59.60	19.44	61.26	19.84

TABLE 8
Stockout (no. of days)

	no demurrage for Chinese		demurrage for all ships	
	2 unloaders	3 unloaders	2 unloaders	3 unloaders
1987	0.00			
1988	0.00			
1989	0.00	0.00		
1990	0.00	0.00	0.00	0.00
1991	0.00	0.00		
1992	0.01	0.00	0.00	0.02
1993	0.00	0.00		
1994	0.07	0.04	0.01	0.05
1995	0.01	0.00		
1996	0.02	0.02	0.03	0.00
1997				
1998	0.00	0.00	0.00	0.00
1999				
2000	0.00	0.04	0.01	0.00

CHART 1 INPUT SEGMENT

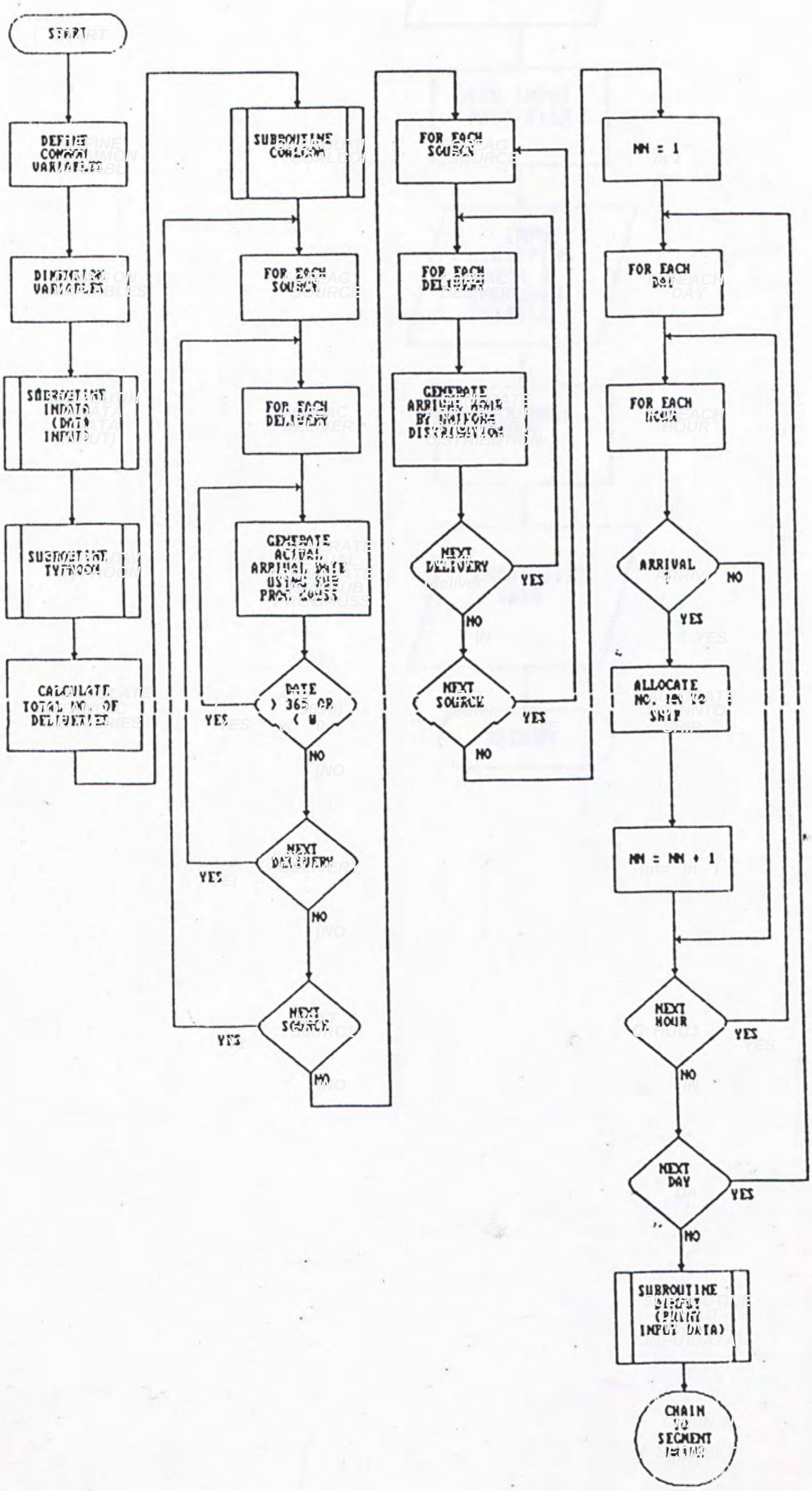


CHART 2 SUBROUTINE INDATA (DATA INPUT)

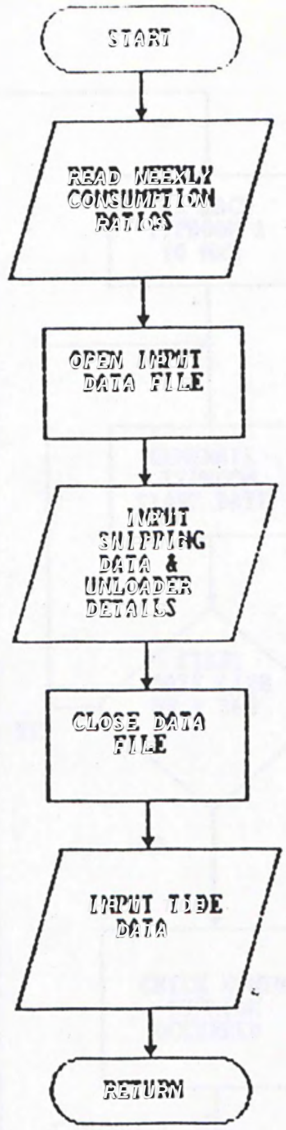


CHART 3 SUBROUTINE TYPHOON

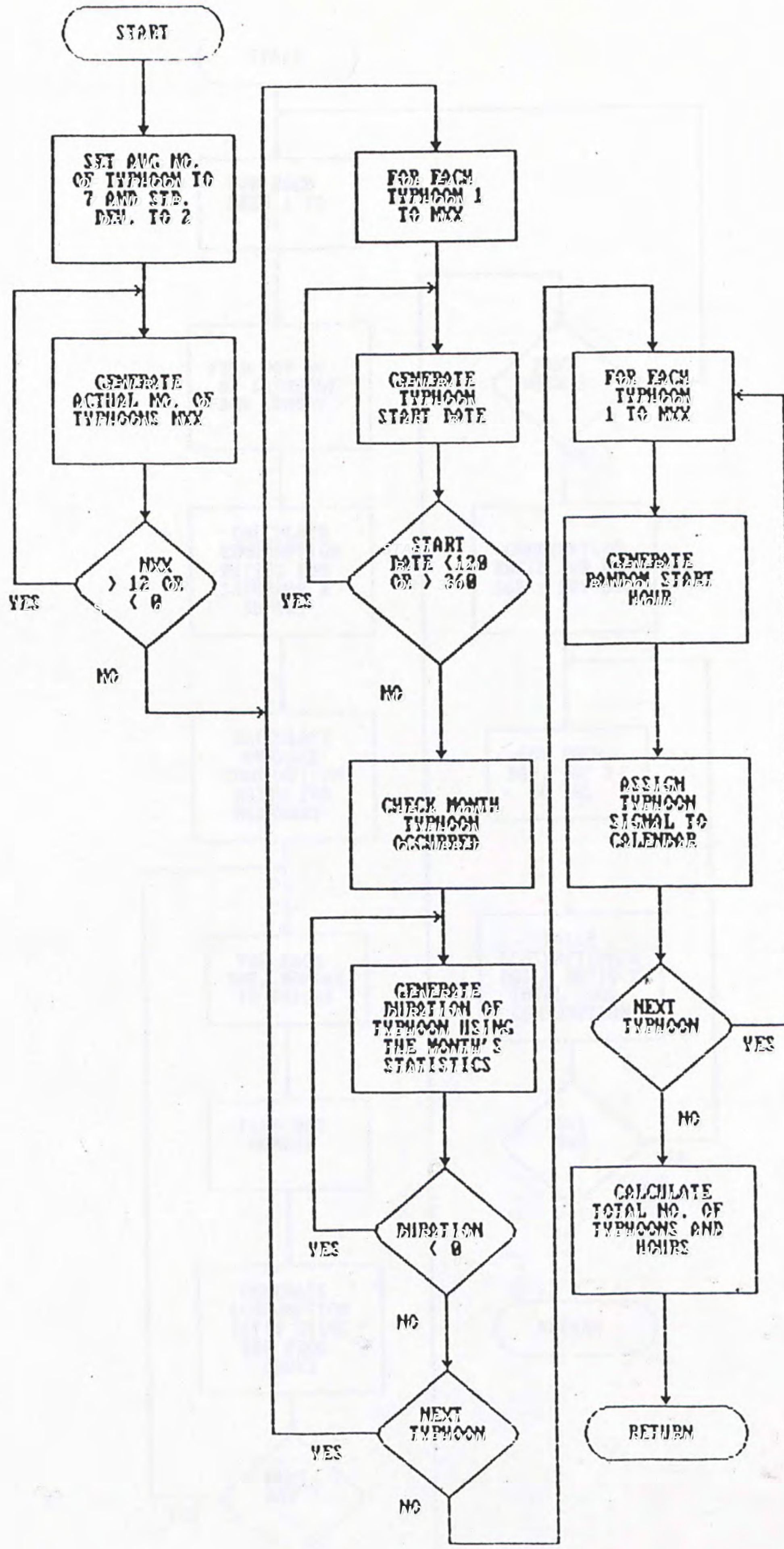


CHART 4 SUBROUTINE COALCON

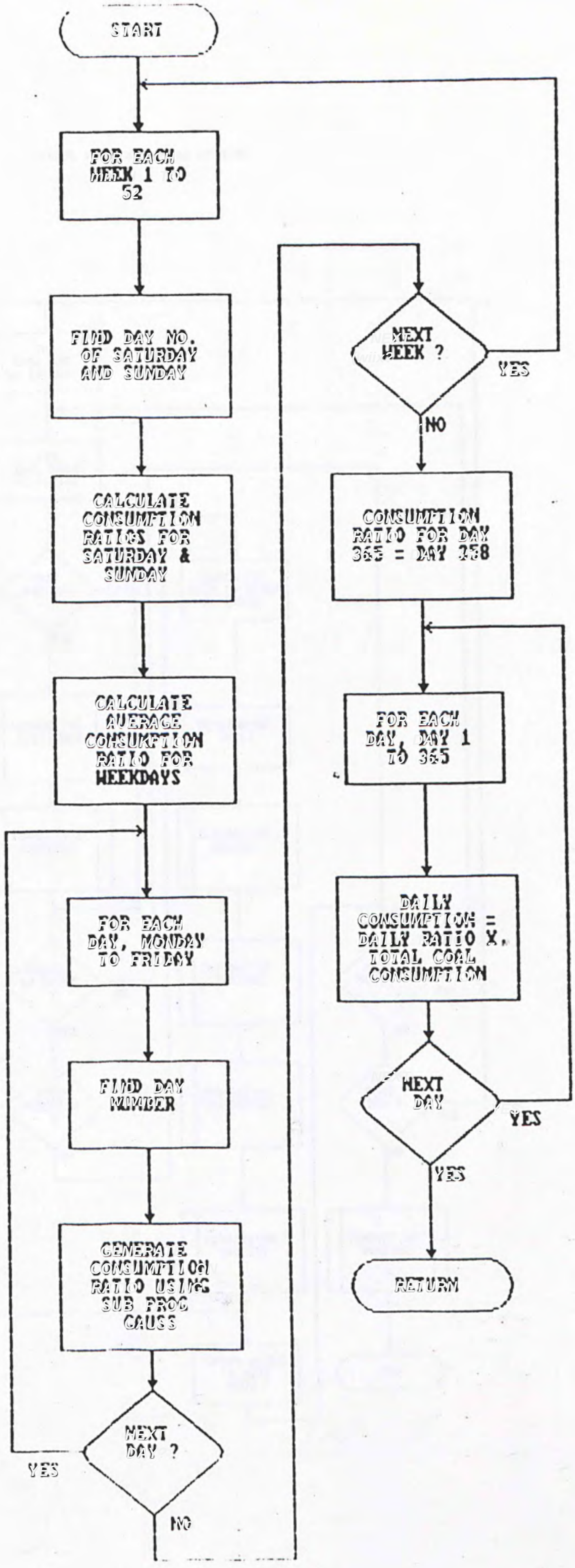


CHART 5 MAIN PROGRAM SEGMENT

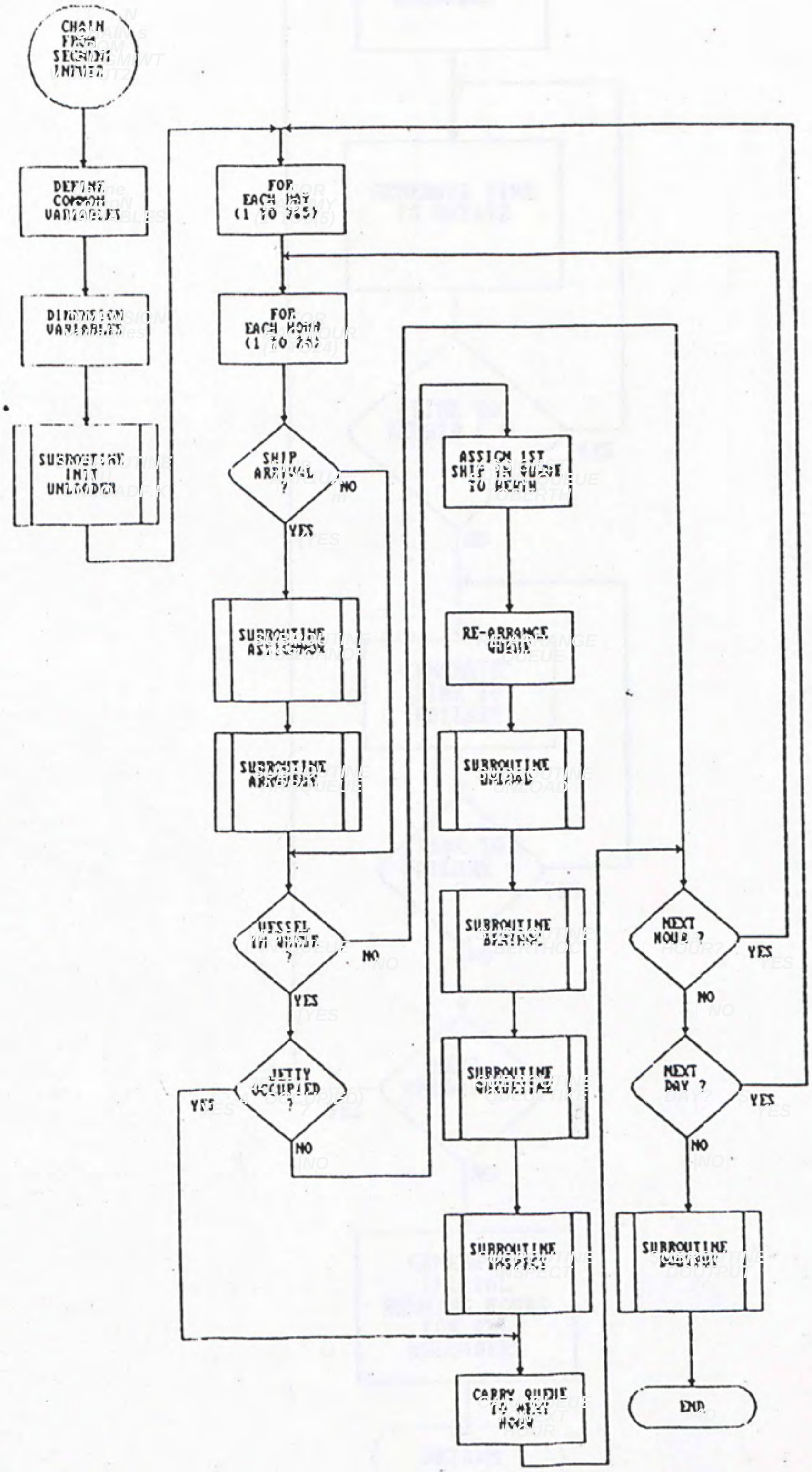


CHART 6 SUBROUTINE INITUNLOADER

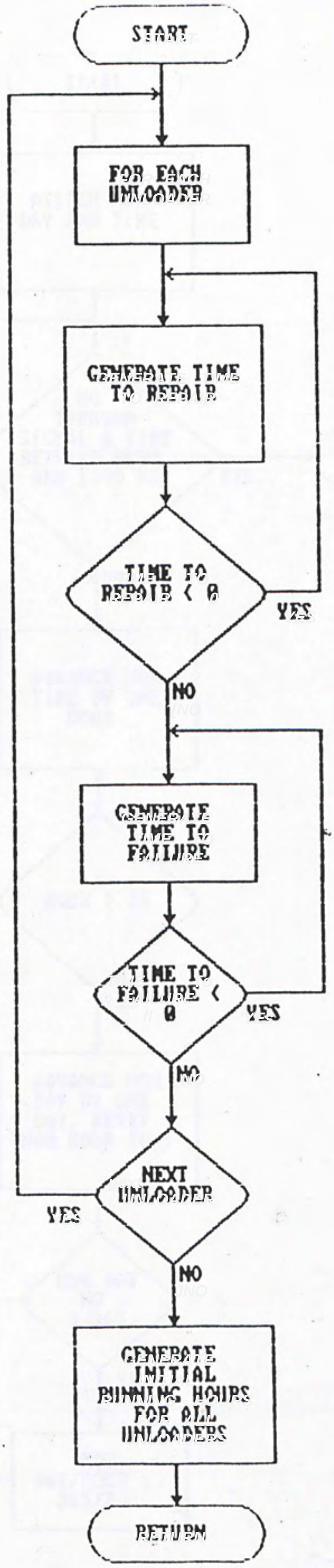


CHART 7 SUBROUTINE ASSIGNOR

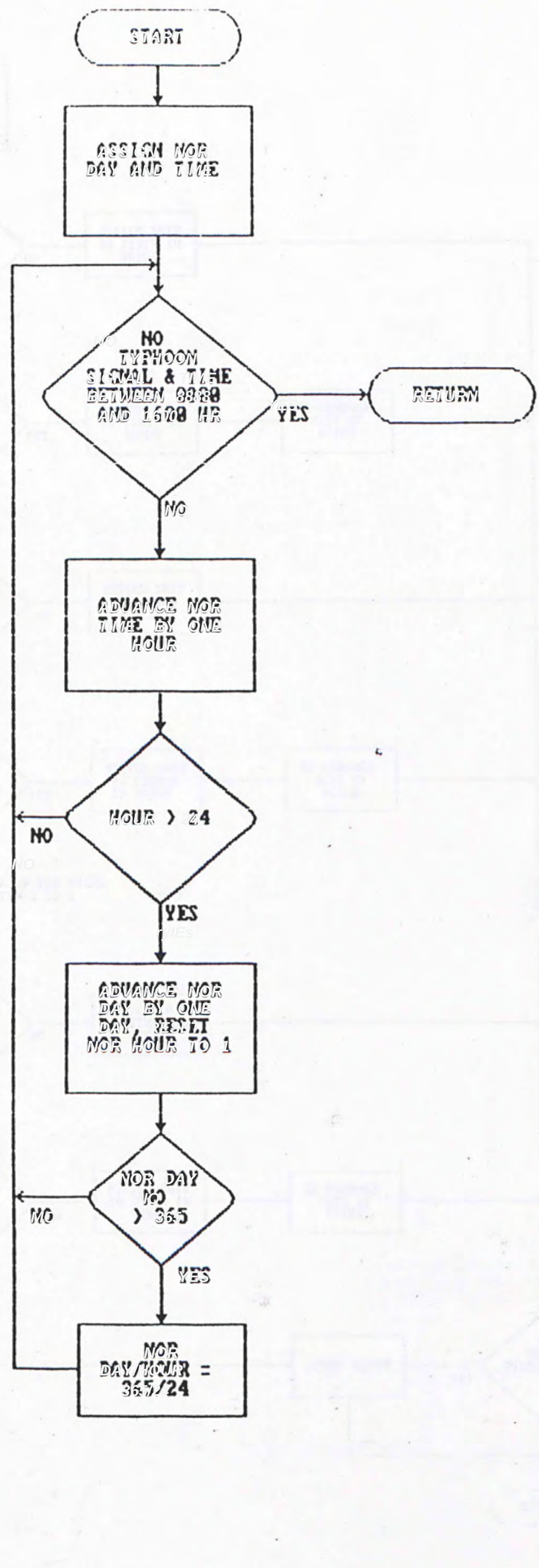


CHART 8 SUBROUTINE ARRQUEUE

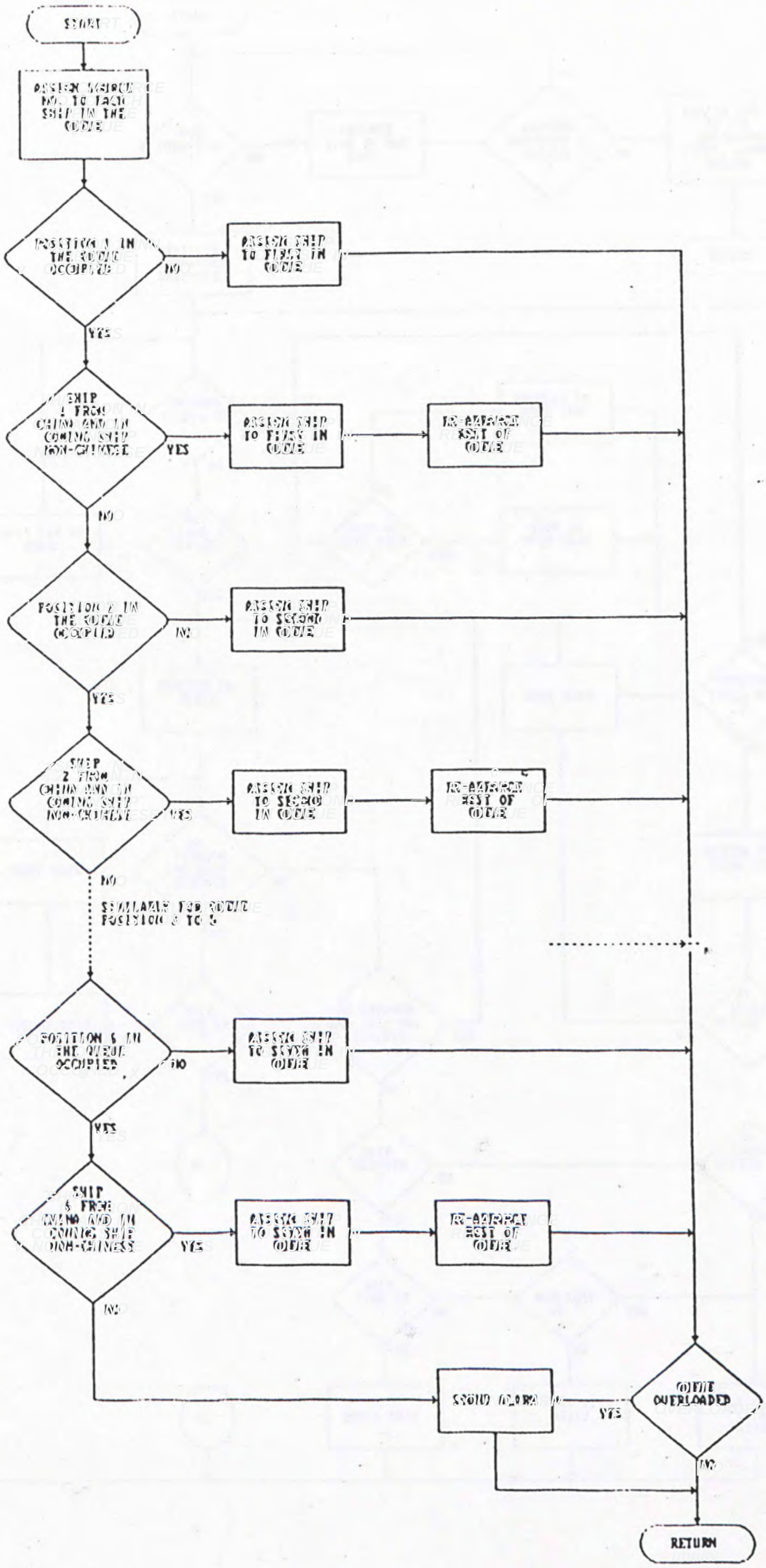


CHART 9 SUBROUTINE UNLOAD (PART 1)

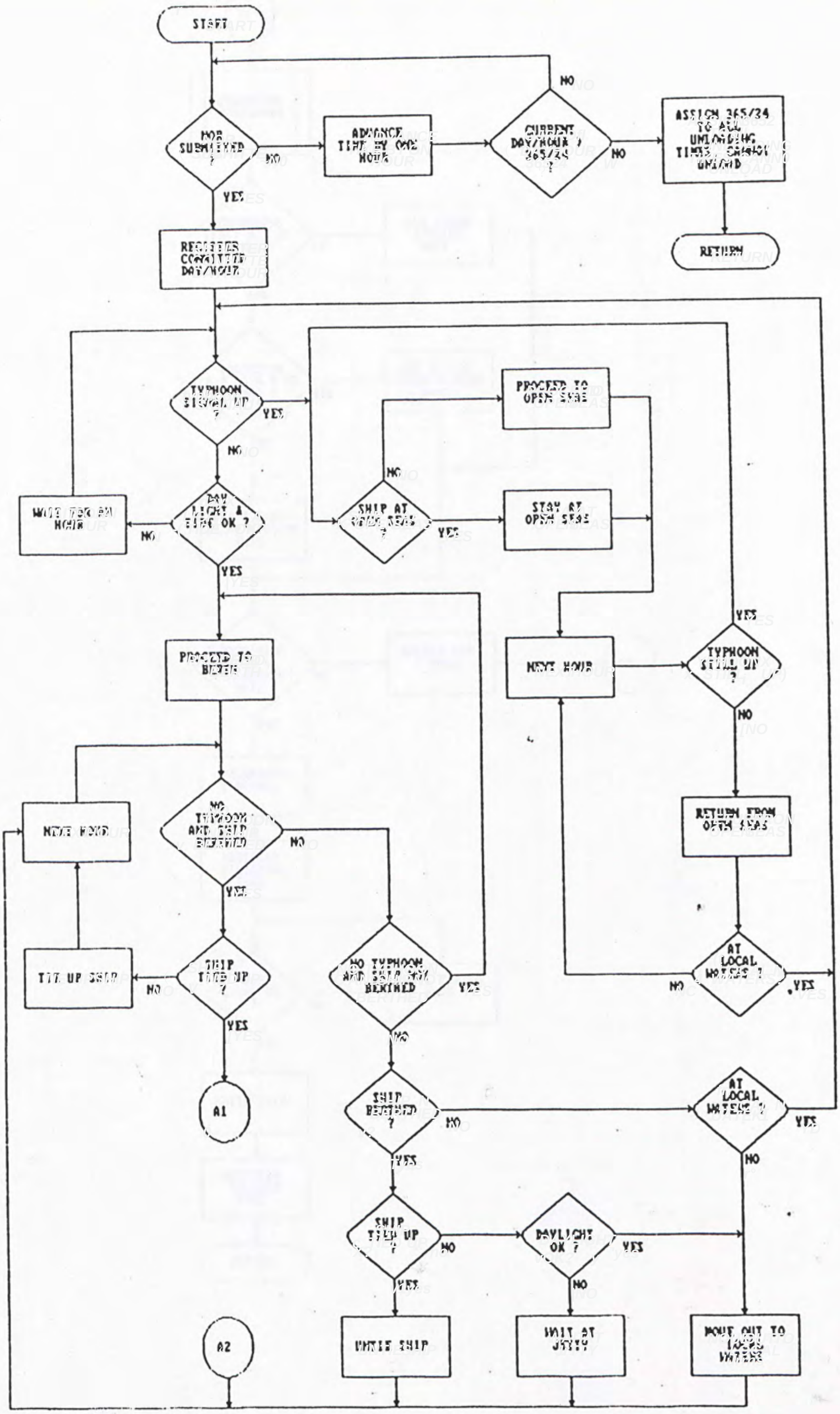


CHART 14 SUBROUTINE UNLOAD (PART 2)

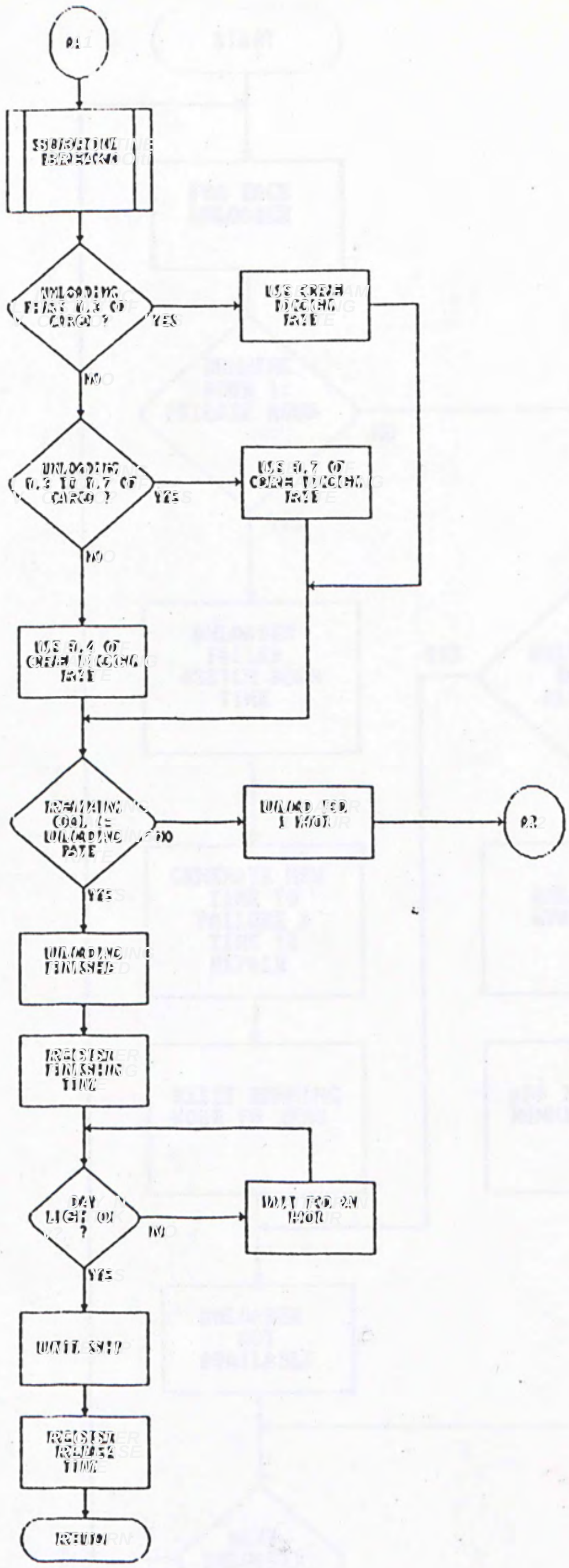


CHART 11 SUBROUTINE BREAKDOWN

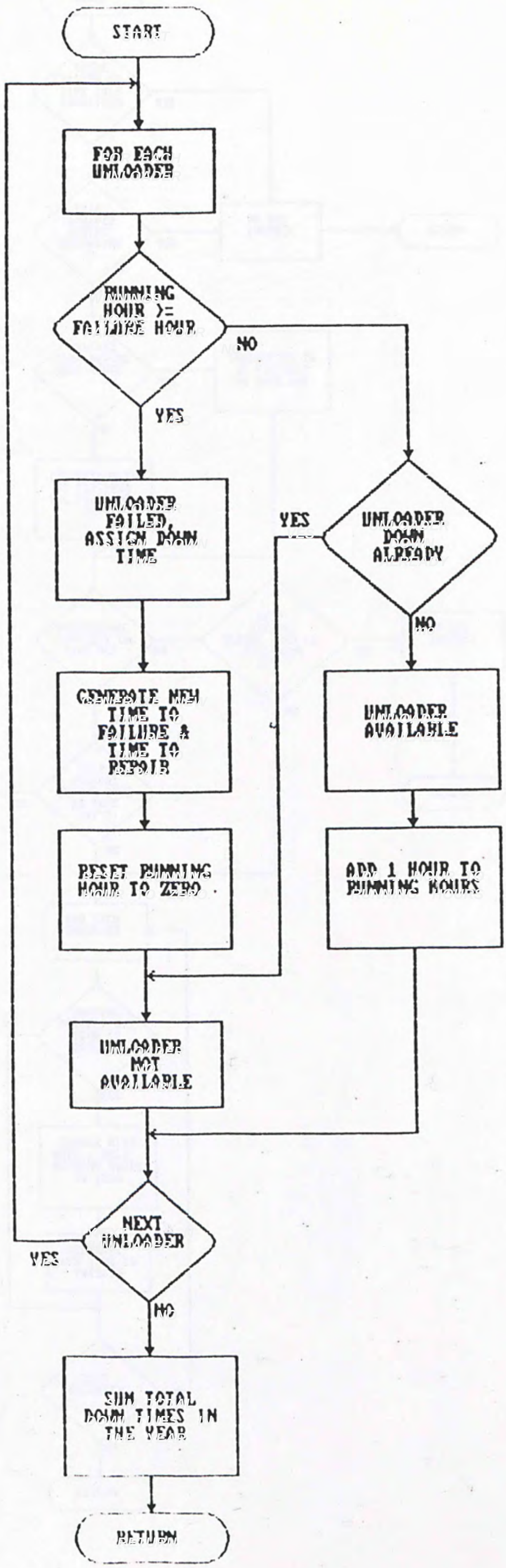
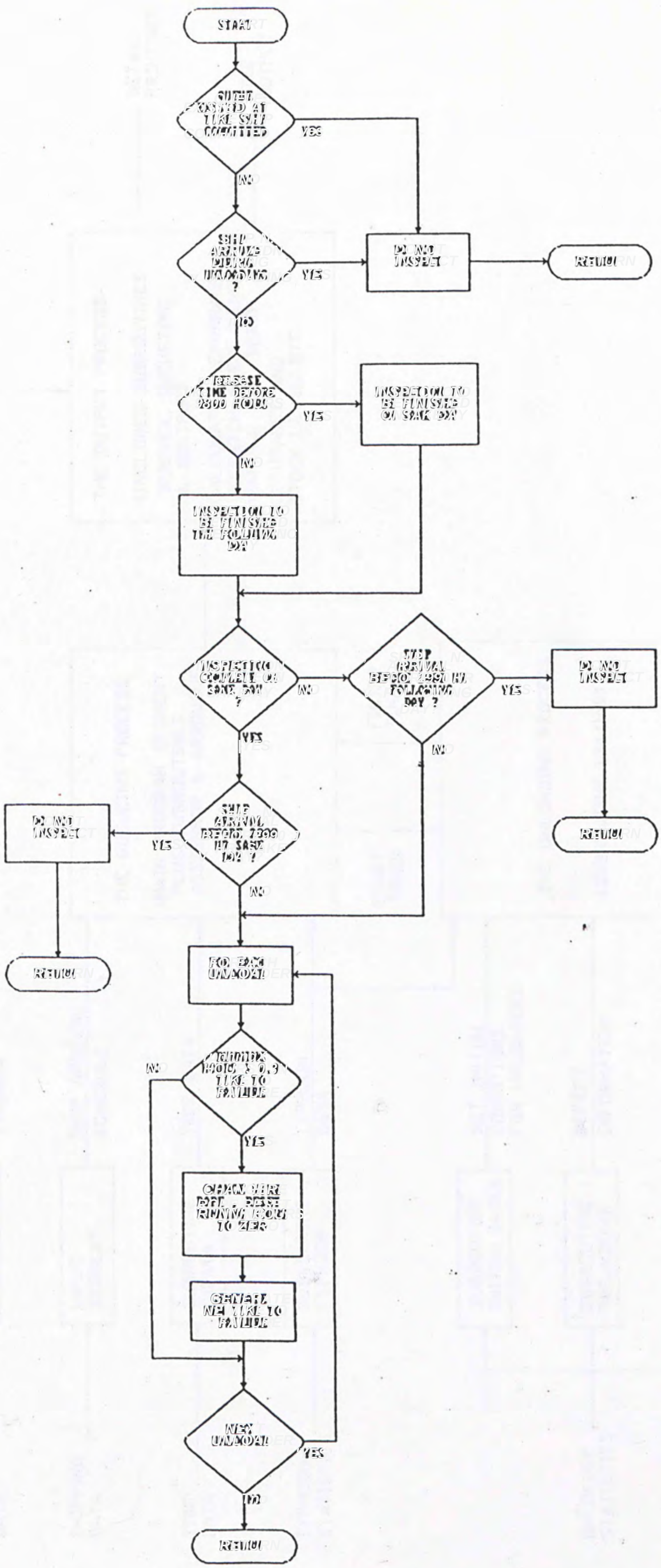


CHART 12 SUBROUTINE INSPECT



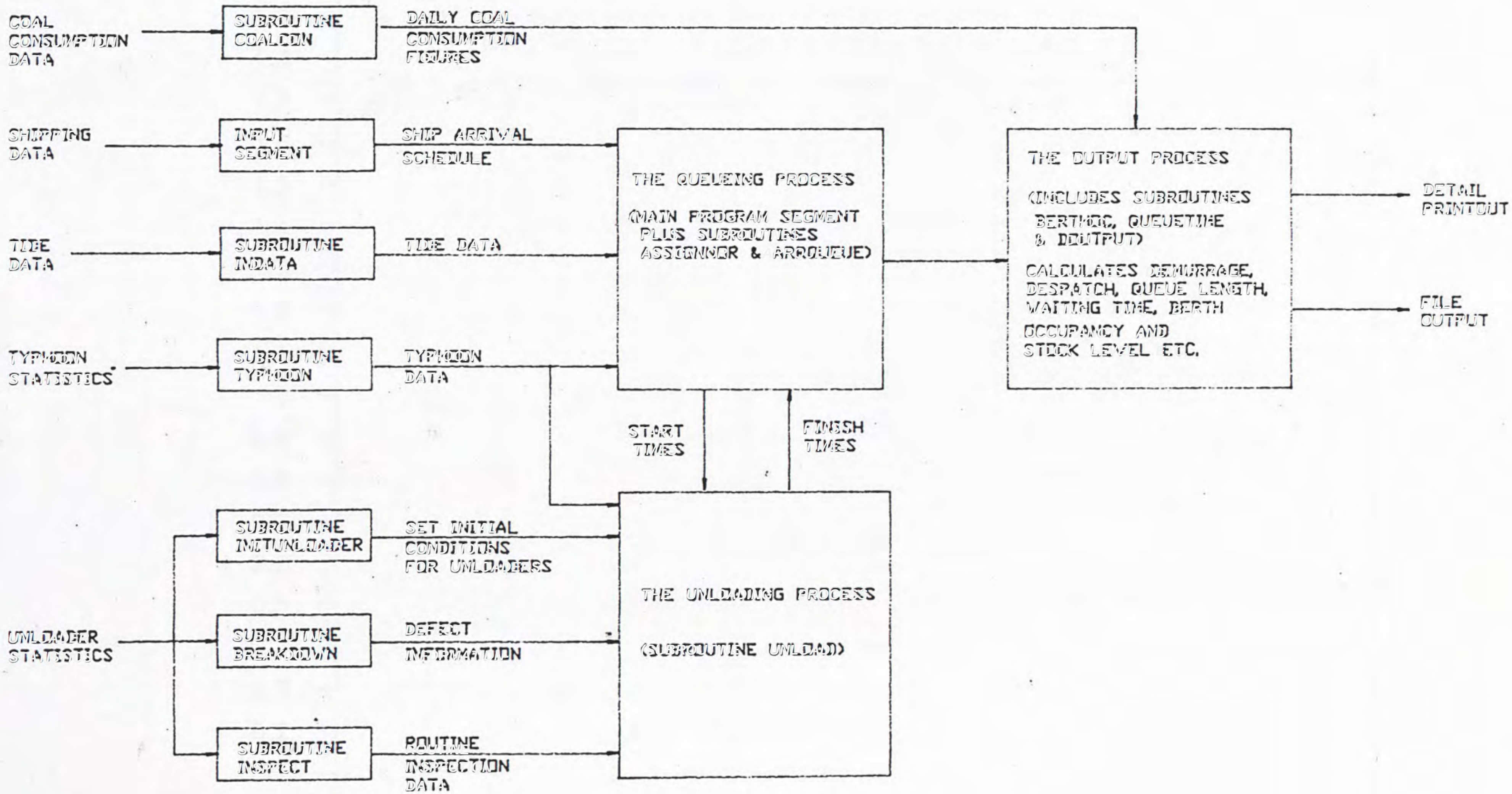


FIG. 1 SYSTEM OVERVIEW

Figure 2

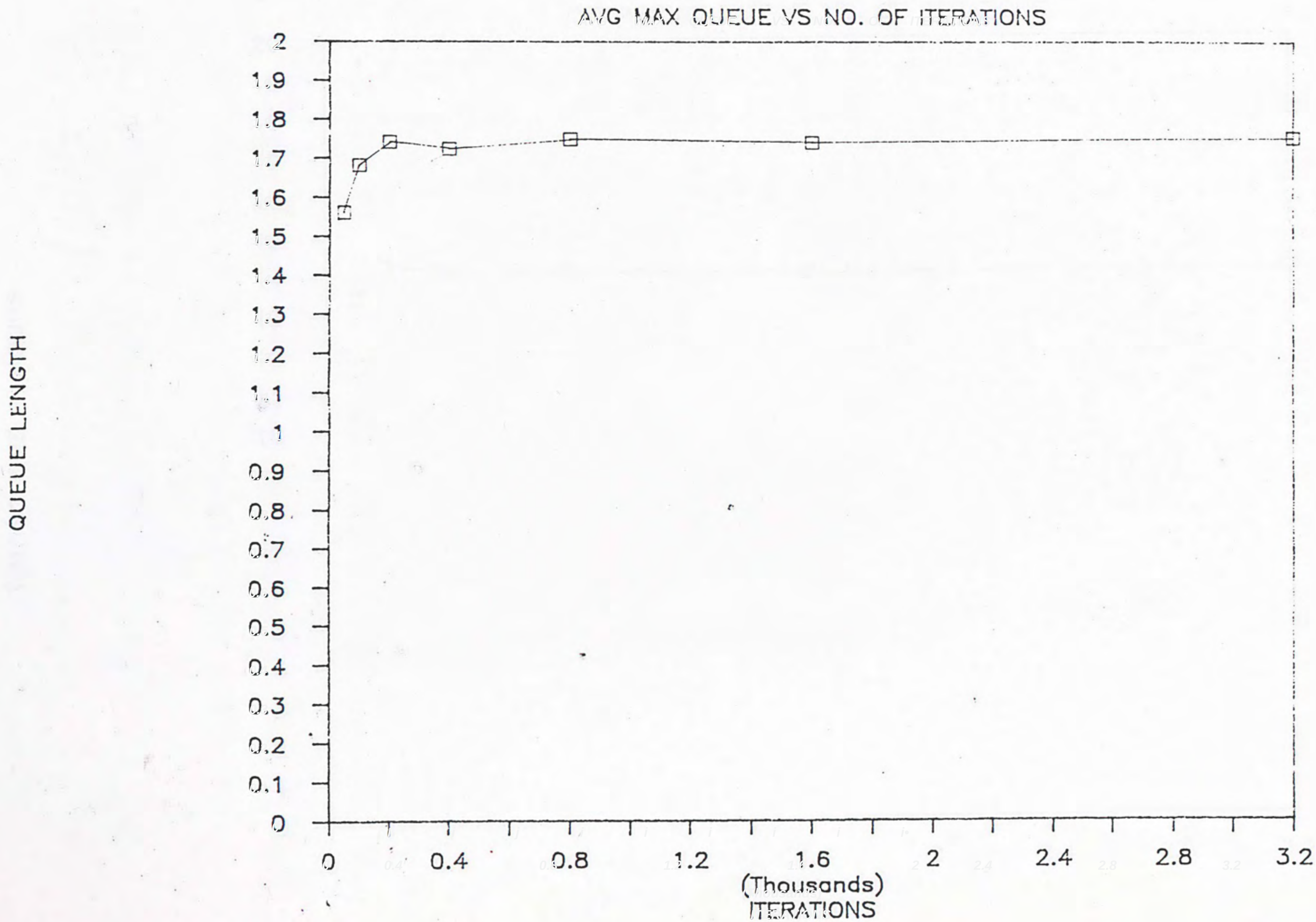

AVG MAX QUEUE VS NO. OF ITERATIONS
QUEUE LENGTH
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
(Thousands)
ITERATIONS

Fig 3

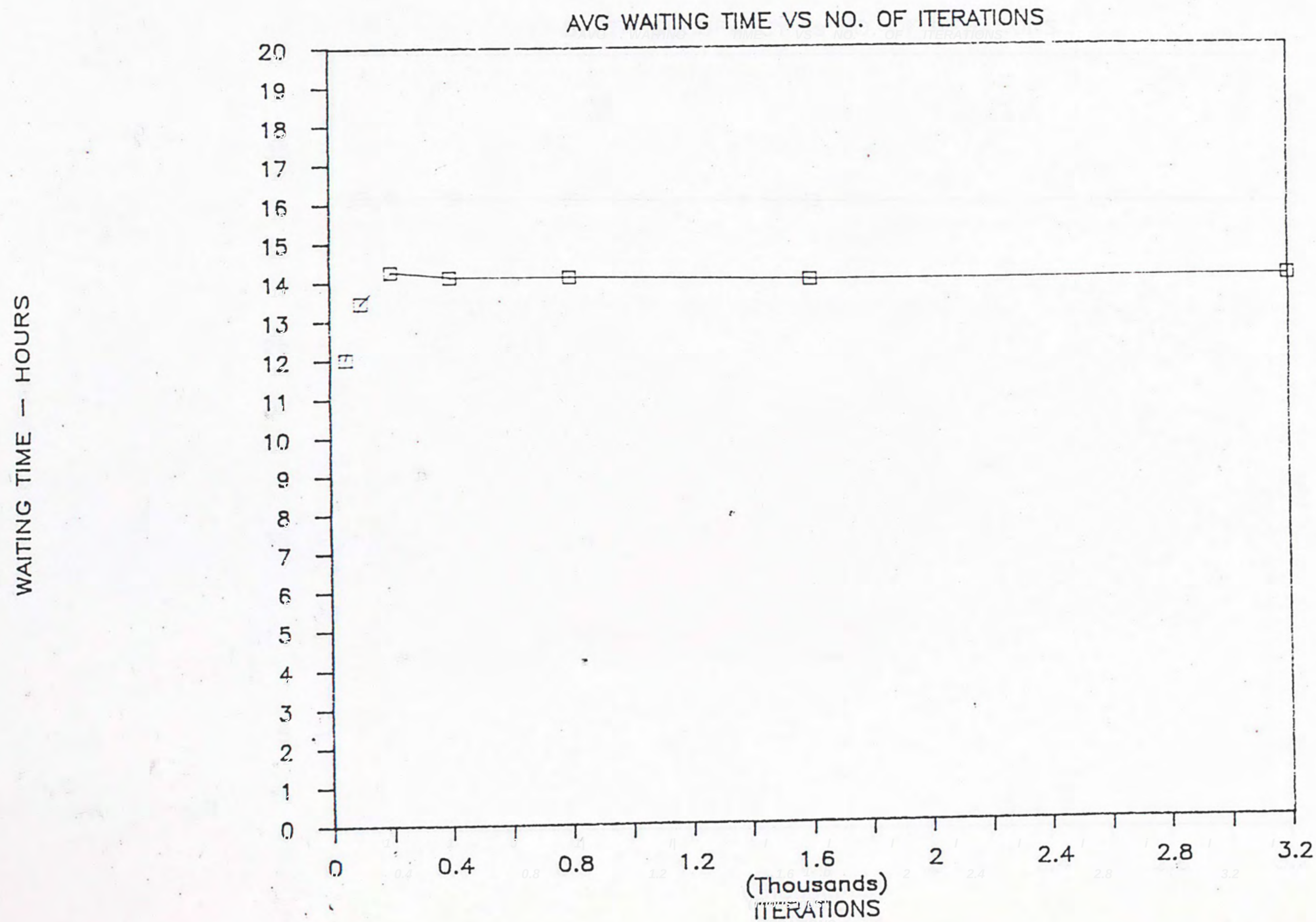
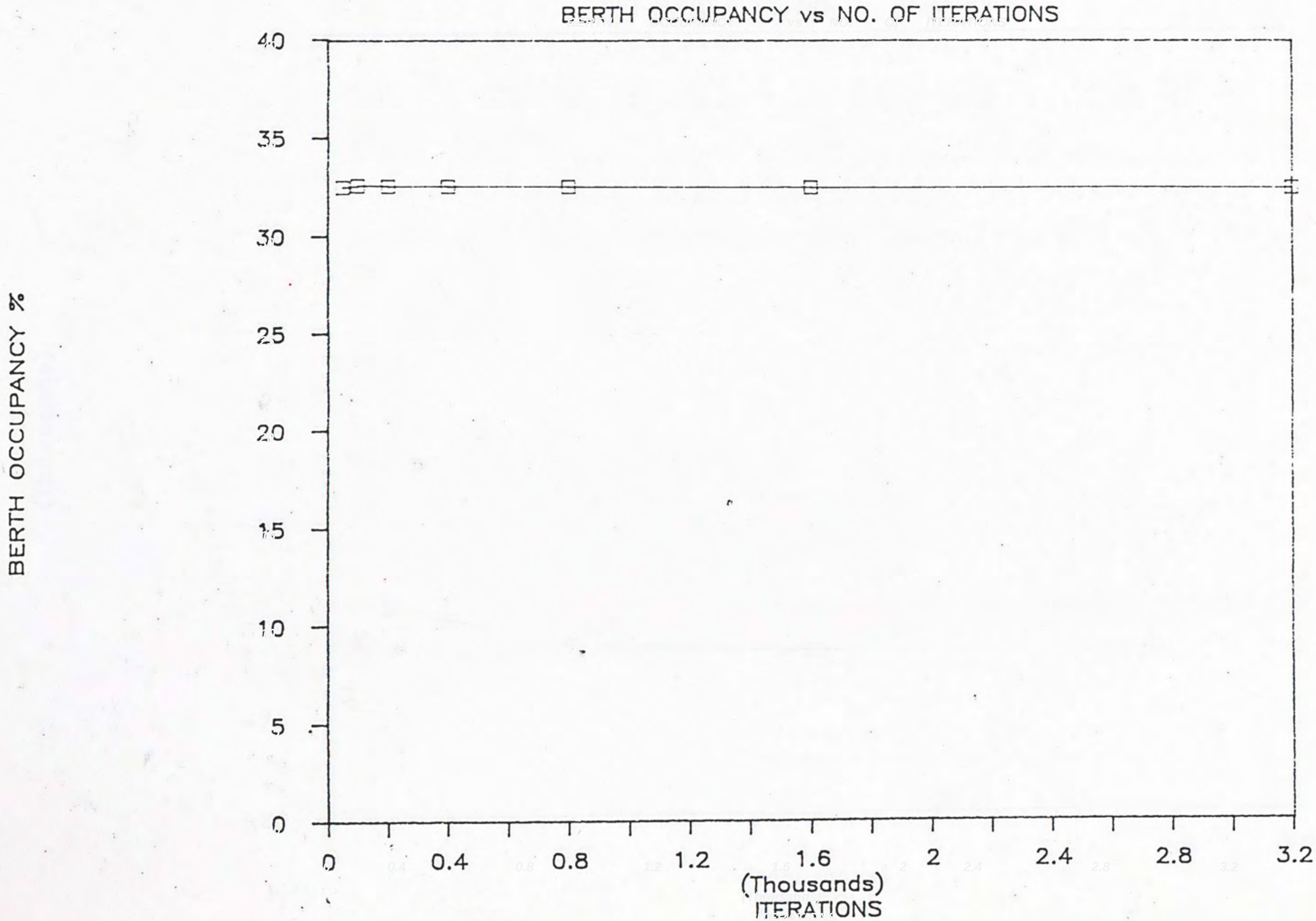

AVG WAITING TIME VS NO. OF ITERATIONS
WAITING TIME — HOURS
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
(Thousands)
ITERATIONS

Fig. 4



BERTH OCCUPANCY vs NO. OF ITERATIONS
BERTH OCCUPANCY %
40
35
30
25
20
15
10
5
0
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
(Thousands)
ITERATIONS

Fig. 5

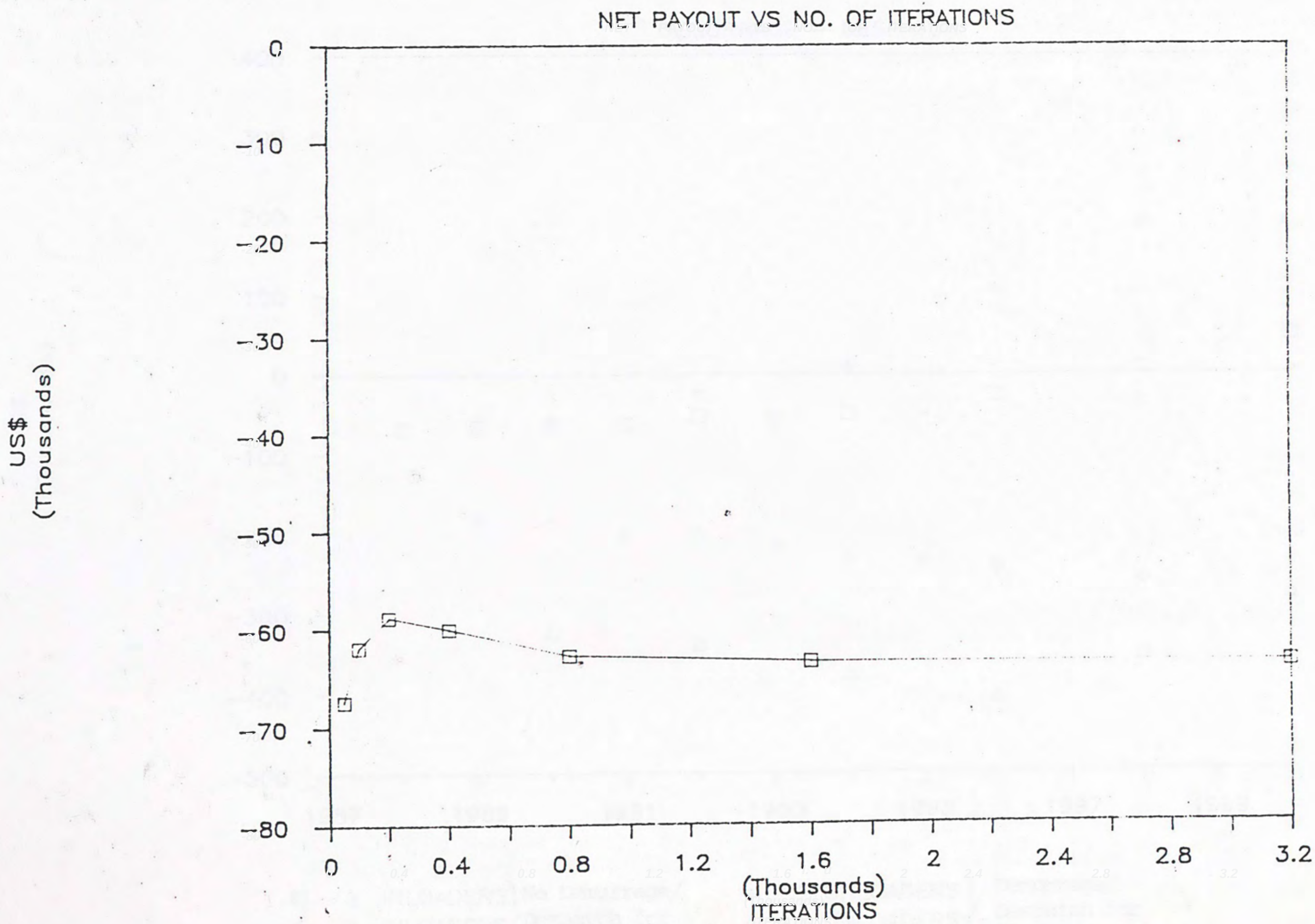

NET PAYOUT VS NO. OF ITERATIONS
0
-10
-20
-30
-40
-50
-60
-70
-80
US$
(Thousands)
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
(Thousands)
ITERATIONS

Fig 6

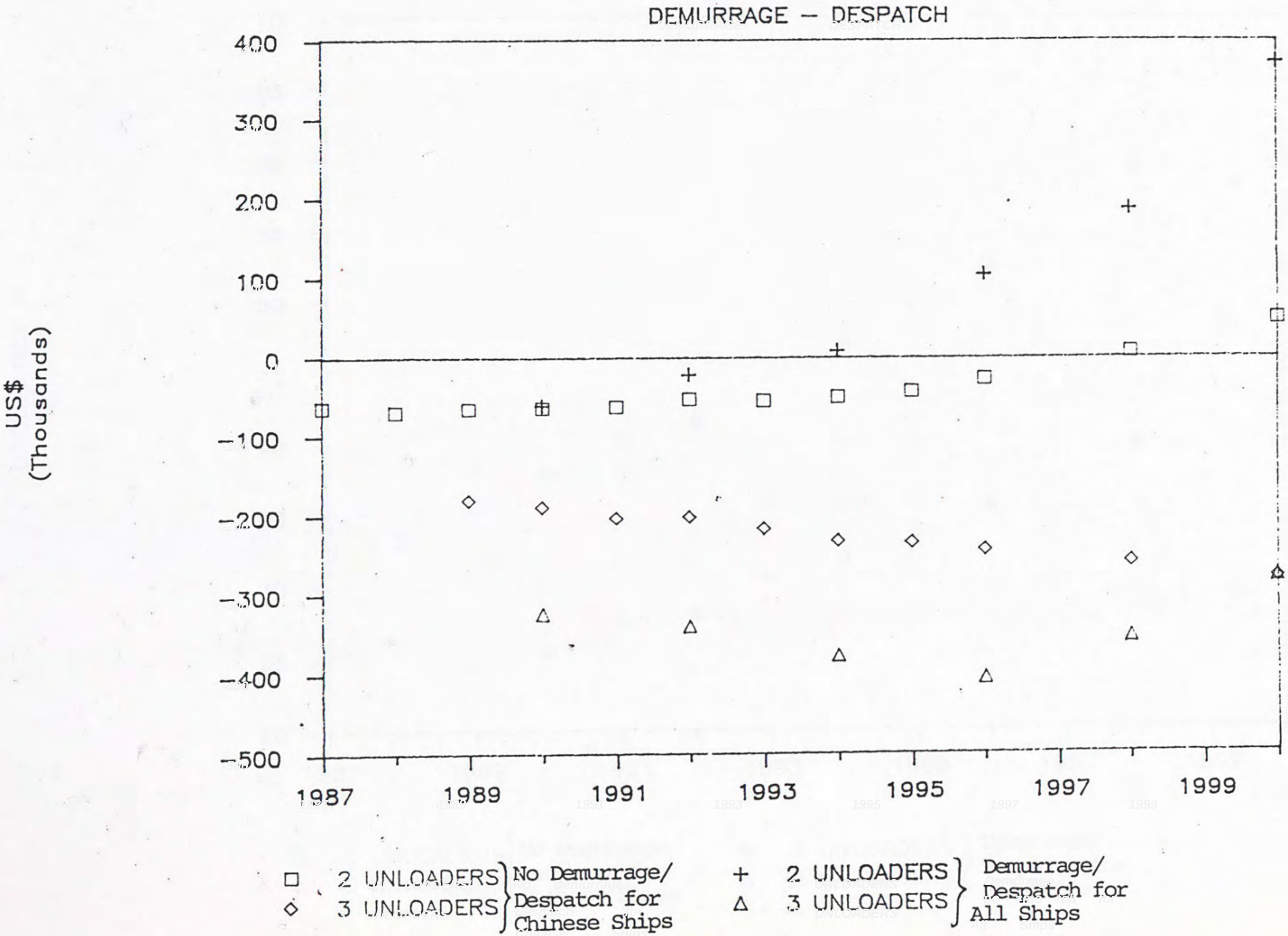

DEMURRAGE — DESPATCH
US$
(Thousands)
400
300
200
100
0
−100
−200
−300
−400
−500
1987
1989
1991
1993
1995
1997
1999
2 UNLOADERS
3 UNLOADERS
No Demurrage/ Despatch for Chinese Ships
2 UNLOADERS
3 UNLOADERS
Demurrage/ Despatch for All Ships

Fig. 7

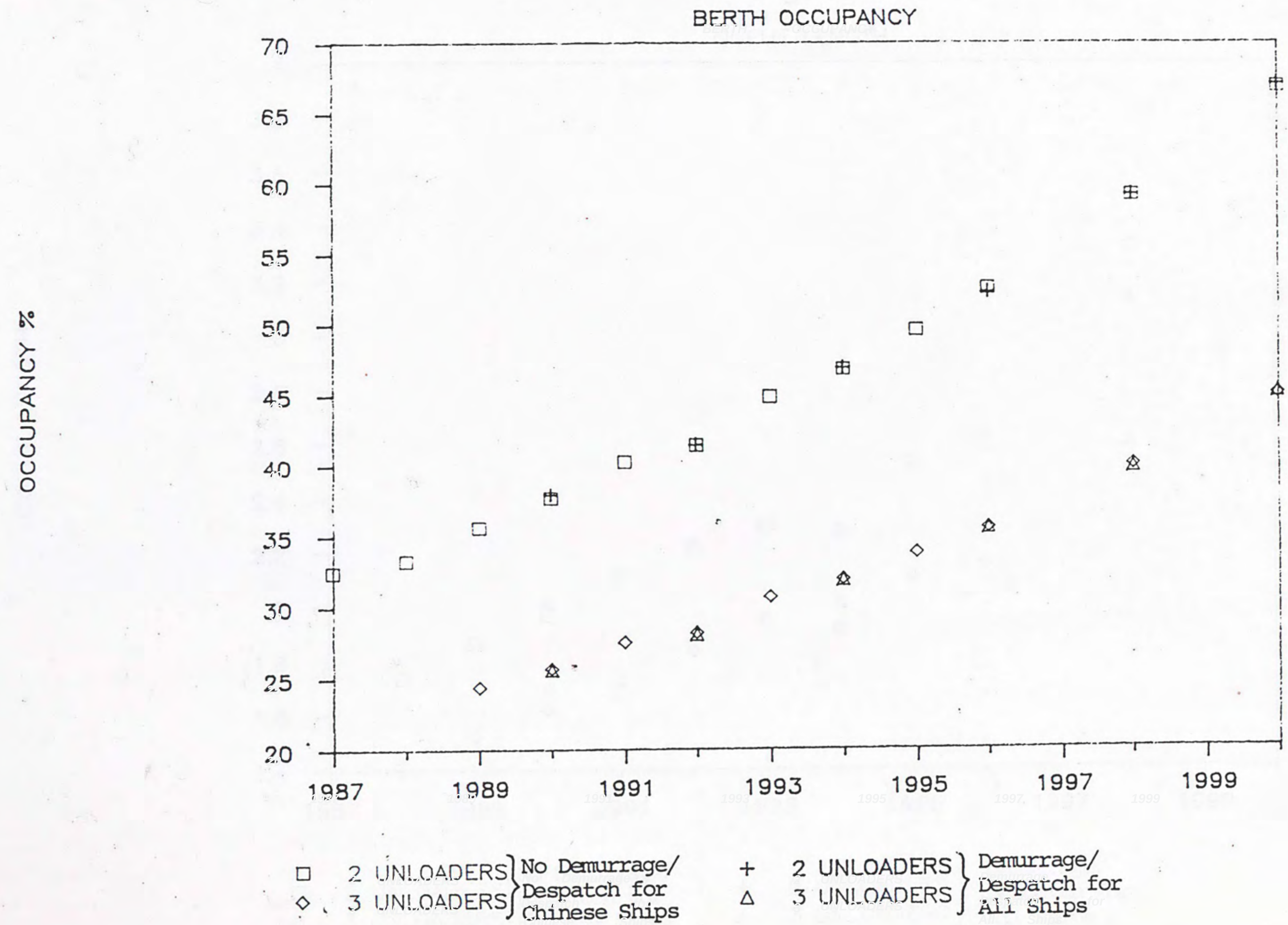

BERTH OCCUPANCY
OCCUPANCY %
70
65
60
55
50
45
40
35
30
25
20
1987
1989
1991
1993
1995
1997
1999
2 UNLOADERS
3 UNLOADERS
No Demurrage/ Despatch for Chinese Ships
2 UNLOADERS
3 UNLOADERS
Demurrage/ Despatch for All Ships

Fig. 8

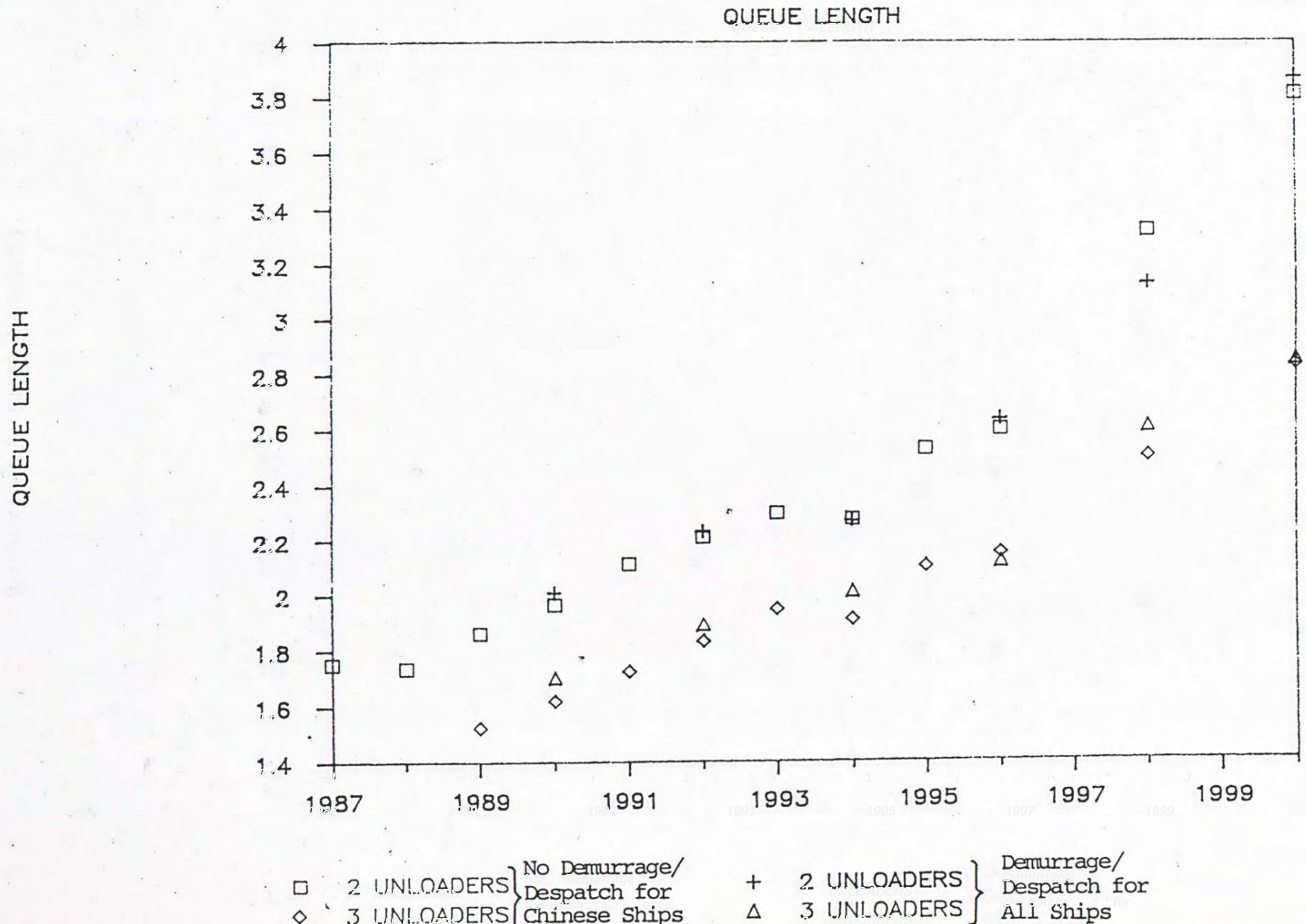
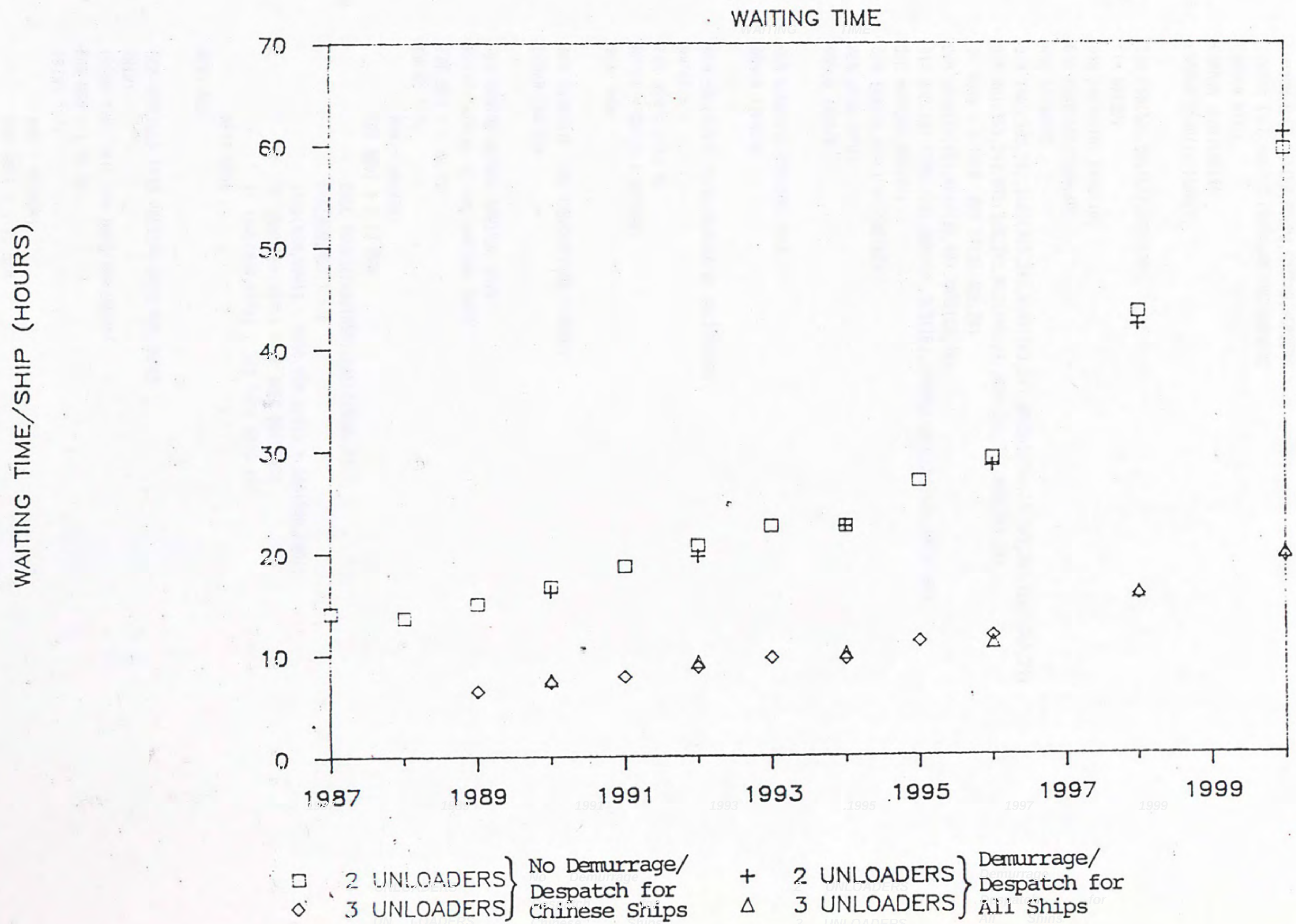

QUEUE LENGTH
QUEUE LENGTH
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1987
1989
1991
1993
1995
1997
1999
2 UNLOADERS
3 UNLOADERS
No Demurrage/ Despatch for Chinese Ships
2 UNLOADERS
3 UNLOADERS
Demurrage/ Despatch for All Ships

Fig 9


WAITING TIME
WAITING TIME/SHIP (HOURS)
70
60
50
40
30
20
10
0
1987
1989
1991
1993
1995
1997
1999
2 UNLOADERS
3 UNLOADERS
No Demurrage/
Despatch for
Chinese Ships
2 UNLOADERS
3 UNLOADERS
Demurrage/
Despatch for
All Ships

Appendix 1 Programme Listings

```
DEFINT I-N
COMMON ITERATION,RUNN,ITIDE(2)
COMMON NAAS(2),IT(2)
COMMON DMM(1),DSS(1),CC(1),ATE(1),ICHUL(1),ISOURCE(1),ISCAT(1)
COMMON NNTOT,NHBTH,ITBER,NHRET,CSLI
COMMON IULA,AMTTFA,FDEVA,AMTTRA,REPDEVA
COMMON IULB,AMTTFB,FDEVB,AMTTRB,REPDEVB
COMMON IULC,AMTTFC,FDEVC,AMTTRC,REPDEVC
COMMON NXX,L
COMMON ILAYTIME(1)
COMMON ISAD(1),ISAH(1)

DIM CSW(52),CW(365),CS(365)
DIM ND(20)
DIM PAETA(10),PASD(10)
DIM ISAD(60),ISAH(60)
REM $DYNAMIC
DIM ISAS(365,24),IAAS(365,24),NAAS(365,24),NB(365,24),IT(365,24),ILAY(365,24)
DIM NQ1(365,24),NQ2(365,24),NQ3(365,24),NQ4(365,24),NQ5(365,24)
IF RUNN = 0 THEN  DIM ITIDE(365,24)
DIM IPAD(10,40),NCAT(10,40),IAAD(10,40)
DIM ATE(10),ICHUL(10),DMM(10),DSS(10),ISOURCE(60),CC(365),ISCAT(60)
DIM NDD(20),DUR(20)
DIM IAA(10,40),ILAYTIME(60)
REM DATA INPUT
GOSUB INDATA

REM GENERATE TYPHOON DATA
GOSUB TYPHOON

REM CALCULATE TOTAL NUMBER OF DELIVERIES
NNTOT = 0
FOR NSN = 1 TO NS
NNTOT = NNTOT + ND(NSN)
NEXT NSN

REM GENERATE COAL CONSUMPTION FIGURES
GOSUB COALCON

REM DERIVE ACTUAL ARRIVAL DAYS
PRINT "DERIVE ACTUAL ARRIVAL DAYS"
FOR NSN = 1 TO NS
PRINT ".";
        NDN = ND(NSN)
        FOR ND01 = 1 TO NDN
100             CALL GAUSS(PASD(NSN),PAETA(NSN),A)
                IAA(NSN,ND01) = A
                IAAD(NSN,ND01) = IPAD(NSN,ND01) + IAA(NSN,ND01)
                IF IAAD(NSN,ND01) <= 0 THEN GOTO 100
                IF IAAD(NSN,ND01) > 365 THEN GOTO 100
        NEXT ND01
NEXT NSN

REM SCHEDULE INTO ARRIVAL DAYS AND HOURS
PRINT
PRINT "PUT INTO ARR DAYS AND HOURS"
FOR NSN = 1 TO NS
PRINT ".";
        NDN = ND(NSN)
        FOR ND01 = 1 TO NDN
```

```
                N = IAAD(NSN,ND01)
110             RANDOMIZE TIMER
                R = RND
                X = R*23 + 1
                IH = X
                IF IAAS(N,IH) > 0 THEN GOTO 110
                IAAS(N,IH) = NCAT(NSN,ND01)
                ISAS(N,IH) = NSN
                ILAY(N,IH) = IAA(NSN,ND01)
         NEXT ND01
     NEXT NSN
     REM PUT ARRIVALS INTO NUMBER SCHEDULE
     NN = 1
     PRINT
     PRINT "PUT INTO NUMBER SCHEDULE "
     FOR N = 1 TO 365
         FOR IH = 1 TO 24
         IF IAAS(N,IH) = 0 THEN GOTO 120
         ISCAT(NN) = IAAS(N,IH)
         NAAS(N,IH) = NN
         ISAD(NN) = N
         ISAH(NN) = IH
         ISOURCE(NN) = ISAS(N,IH)
         ILAYTIME(NN) = ILAY(N,IH)
         NN = NN + 1
120      NEXT IH
     NEXT N
     GOSUB DINPUT
     CHAIN "MAIN2"
     end

     INDATA :
     REM INPUT COAL CONSUMPTION PATTERN
     FOR I=1 TO 52
     READ CSN(I)
     NEXT I
     DATA 1.51,1.50,1.50,1.49,1.49,1.48,1.46,1.48,1.49,1.53
     DATA 1.55,1.62,1.65,1.68,1.70,1.74,1.83,1.93,2.01,2.05
     DATA 2.08,2.17,2.20,2.22,2.24,2.30,2.35,2.38,2.41,2.38
     DATA 2.36,2.34,2.33,2.33,2.30,2.29,2.29,2.29,2.29,2.22
     DATA 2.03,1.95,1.90,1.82,1.79,1.76,1.73,1.71,1.69,1.67
     DATA 1.63,1.61

     INPUT "NAME OF DATA FILE TO BE USED (DEFAULT MTSDATA.DAT) ", FILE$
     IF LEFT$(FILE$,1) = " " OR LEFT$(FILE$,1) = "" THEN FILE$ = "MTSDATA.DAT" : GOTO 10
     PRINT FILE$

     REM OPEN INPUT FILE
10   PRINT "READING FROM DISK FILE -- DO NOT INTERRUPT"
     OPEN "I", #1, FILE$
     INPUT #1, CCTOT,CSLI,CCSTD,CSSAT,CSSUN
     INPUT #1, IULA,IULB,IULC
     INPUT #1, AMTTFA,AMTTFB,AMTTFC
     INPUT #1, AMTTRA,AMTTRB,AMTTRC
     INPUT #1, FDEVA,FDEVB,FDEVC
     INPUT #1, REPDEVA,REPDEVB,REPDEVC
     INPUT #1, ITBER,NWRET,NWBTH
     INPUT #1, NS,NVTOT
```

```
      REM NUMBER OF SOURCE = NS AND NUMBER OF DELIVERIES = ND FROM SOURCE NSN
      REM INPUT NUMBER OF DELIVERIES FROM EACH SOURCE
      FOR NSN = 1 TO NS
      INPUT #1, ND(NSN)
      NEXT NSN


      FOR NSN = 1 TO NS
      INSD = ND(NSN)
      IF INSD = 0 THEN GOTO 300
      REM INPUT PLANNED ARRIVAL DAYS OF EACH DEL FOR THE SOURCE
      FOR ND01 = 1 TO INSD
      INPUT #1, IPAD(NSN,ND01)
      NEXT ND01
      REM INPUT CATEGORY OF EACH DEL FOR THE SOURCE
      FOR ND01 = 1 TO INSD
      INPUT #1, NCAT(NSN, ND01)
      NEXT ND01
300   NEXT NSN
      REM INPUT DELAYS AND STANDARD DEVIATIONS FOR EACH SOURCE
      FOR NSN = 1 TO NS
      INPUT #1, PAETA(NSN),PASD(NSN)
      NEXT NSN
      REM INPUT CRITERIA FOR EACH CLASS OF VESSELS
      FOR NVT = 1 TO NVTOT
      INPUT #1, ATE(NVT),ICHUL(NVT),DMM(NVT),DSS(NVT)
      NEXT NVT
      CLOSE #1
      IF RUNN = 0 THEN GOSUB TIDE ELSE PRINT "TIDE DATA ALREADY LOADED "
      PRINT "DISK ACCESS COMPLETED"
      RETURN


      COALCON :
      PRINT "GENERATING CONSUMPTION FIGURES"
      PRINT "1=========1=========1=========1=========1=========1="
      FOR IW = 1 TO 52
      PRINT ".";
      NSAT = (IW-1) * 7 + 6
      NSUN = (IW-1) * 7 + 7
      CC(NSAT) = (CSW(IW) * CSSAT) / (CSSAT + CSSUN + 5)
      CC(NSUN) = (CSW(IW) * CSSUN) / (CSSAT + CSSUN + 5)
      AVLD = CSW(IW) / (CSSUN + CSSAT + 5)
      FOR N = 1 TO 5
      NX = (IW - 1) * 7 + N
      CALL GAUSS (CCSTD, AVLD,XLD)
      CC(NX) = XLD
      NEXT N
      NEXT IW
      CC(365) = CC(358)
      TESTTOT = 0
      FOR N = 1 TO 365
      CC(N) = CC(N) * CCTOT/100
```

```
        TESTTOT = TESTTOT + CC(N)
        NEXT N
        PRINT
        RETURN

        REM TIDE DATA
        TIDE :
        PRINT "LOADING TIDE DATA FROM DISK "
        OPEN "I",#2,"TIDEDATA.DAT"
        FOR N = 1 TO 365
        FOR IH = 1 TO 24
        INPUT #2 , TIDE (N,IH)
        NEXT IH
        NEXT N
        CLOSE #2
        RETURN

        TYPHOON :
        PRINT "GENERATING TYPHOON DATA"
200     ANXX = 7
        STDNXX = 2
        CALL GAUSS (STDNXX, ANXX, X)
        NXX = INT(X)
        IF NXX < 0 OR NXX > 12 THEN GOTO 200
        FOR N = 1 TO NXX
210     AMID = 105
        STDMID = 75
        CALL GAUSS (STDMID, AMID, D)
        ND = INT(D)
        IF ND > 240 OR ND < 0 THEN GOTO 210
        NDD(N) = ND + 120
        IF NDD(N) > 330 THEN
                ADUR = 0.07 : SDUR = 0.03
        ELSEIF NDD(N) > 300 THEN
                ADUR = 0.47 : SDUR = 0.26
        ELSEIF NDD(N) > 270 THEN
                ADUR = 2.07 : SDUR = 1.03
        ELSEIF NDD(N) > 240 THEN
                ADUR = 2.93 : SDUR = 1.47
        ELSEIF NDD(N) > 210 THEN
                ADUR = 2.33 : SDUR = 1.66
        ELSEIF NDD(N) > 180 THEN
                ADUR = 2.53 : SDUR = 1.26
        ELSEIF NDD(N) > 150 THEN
                ADUR = 1.30 : SDUR = 0.65
        ELSE    ADUR = 0.60 : SDUR = 0.30
        END IF
220     CALL GAUSS (SDUR, ADUR,DUR)
        DUR(N)  = INT(DUR * 24)
        IF DUR(N) =< 0 THEN GOTO 220
        NEXT N

        FOR N = 1 TO NXX
        N1 = NDD(N)
        J = 0
        RANDOMIZE TIMER
        R = RND
```

```
      IH1 = INT(R*23) + 1
230   IT(N1,IH1) = 3
      J = J + 1
      IF J => DUR(N) THEN GOTO 250
      IH1 = IH1 + 1
      IF IH1 > 24 THEN GOTO 240
      GOTO 230
240   IH1 = IH1 -24
      N1 = N1 + 1
      GOTO 230
250   NEXT N
      L = 0
      FOR N = 120 TO 365
      FOR IH = 1 TO 24
      IF IT(N,IH) = 3 THEN L = L + 1
      NEXT IH
      NEXT N
      PRINT "NUMBER OF TYPHOONS  = ", NXX
      PRINT "TOTAL TYPHOON HOURS = ", L
      RETURN


      DINPUT :
      BEEP
      PRINT
      INPUT "PRINTER READY ? (Y/N) ", Y$
      IF LEFT$ (Y$,1) = "Y" THEN GOTO 310
      RETURN
310   WIDTH "LPT1:",137
      LPRINT CHR$(15);
      LPRINT CHR$(27);"C";CHR$(6);
      LPRINT CHR$(27);"N";CHR$(6);
      LPRINT CHR$(27);"Q";CHR$(137);
      REM PRINT TABLE 1
      LPRINT "NUMBER OF SOURCE OF COAL USED " , NS
      LPRINT
      LPRINT "PLANNED ARRIVALS "
      LPRINT
      LPRINT "SOURCE  PLANNED  ACTUAL   VESSEL    DELAY : PLANNED   "
      LPRINT " NO.    ARRIVAL  ARRIVAL  CATEGORY  -ACTUAL ARRIVAL   "
      LPRINT "          DAY      DAY              MEAN    STD.DEV.  "
      LPRINT
      FOR NSN = 1 TO NS
         INSN = ND(NSN)
         LPRINT SPC(37);
         LPRINT USING "##.#    ";PAETA(NSN);PASD(NSN)
         IF INSN = 0 THEN LPRINT USING "####     ";NSN; : LPRINT "NO SHIPMENT PLANNED"
         FOR ND01 = 1 TO INSN
               LPRINT USING "####     ";NSN;
               LPRINT USING "###      ";IPAD(NSN,ND01);IAAD(NSN,ND01);NCAT(NSN,ND01)
         NEXT ND01
      NEXT NSN
      LPRINT "TOTAL NUMBER OF DELIVERIES PLANNED " , NNTOT

      REM PRINT TABLE 2
      LPRINT CHR$(12);
```

```
LPRINT "VESSEL DETAILS"
LPRINT
LPRINT "          COAL      DEMURRAGE    DESPATCH   CONTRACT  "
LPRINT "CATEGORY  CARRIED   RATE         RATE       NO. OF HOURS "
LPRINT "                    (US$/HOUR)   (US$/HOUR)  TO UNLOAD"
LPRINT
FOR NVT = 1 TO NVTOT
LPRINT USING "  ##      "; NVT;
LPRINT USING "#######      ";ATE(NVT);
LPRINT USING "####.#      "; DMM(NVT); DSS(NVT);
LPRINT USING "####";ICHUL(NVT)
NEXT NVT
LPRINT
LPRINT "NO. OF HOURS TO TRAVEL FROM LOCAL WATERS TO TYPHOON SHELTER ",NHRST
LPRINT "NO. OF HOURS TO TRAVEL FROM LOCAL WATERS TO JETTY" ,,ITBER
LPRINT "NO. OF HOURS TO BERTH AND TIE UP VESSEL ",,,NHBTH
LPRINT
LPRINT "UNLOADER DETAILS"
LPRINT
LPRINT "CREAM UNLOADING RATE OF UNLOADER NO. 1",IULA,"TONNES/HOUR"
LPRINT "CREAM UNLOADING RATE OF UNLOADER NO. 2",IULB,"TONNES/HOUR"
LPRINT "CREAM UNLOADING RATE OF UNLOADER NO. 3",IULC,"TONNES/HOUR"
LPRINT "MEAN TIME TO FAILURE OF UNLOADER NO. 1",AMTTFA,"RUNNING HOURS"
LPRINT "MEAN TIME TO FAILURE OF UNLOADER NO. 2",AMTTFB,"RUNNING HOURS"
LPRINT "MEAN TIME TO FAILURE OF UNLOADER NO. 3",AMTTFC,"RUNNING HOURS"
LPRINT "STD.DEV. OF MTTF FOR UNLOADER NO. 1", FDEVA,"
LPRINT "STD.DEV. OF MTTF FOR UNLOADER NO. 2", FDEVB
LPRINT "STD.DEV. OF MTTF FOR UNLOADER NO. 3", FDEVC
LPRINT "MEAN TIME TO REPAIR OF UNLOADER NO. 1",AMTTRA,"WORKING HOURS"
LPRINT "MEAN TIME TO REPAIR OF UNLOADER NO. 2",AMTTRB,"WORKING HOURS"
LPRINT "MEAN TIME TO REPAIR OF UNLOADER NO. 3",AMTTRC,"WORKING HOURS"
LPRINT "STD.DEV OF MTTR FOR UNLOADER NO. 1",REPDEVA
LPRINT "STD.DEV OF MTTR FOR UNLOADER NO. 2",REPDEVB
LPRINT "STD.DEV OF MTTR FOR UNLOADER NO. 3",REPDEVC

LPRINT
LPRINT "OTHER INFORMATION"
LPRINT
LPRINT "PLANNED COAL CONSUMPTION ",
LPRINT USING "########";CCTOT,
LPRINT SPC(2);"TONNES"
LPRINT "ACTUAL COAL CONSUMPTION ",
LPRINT USING "########";TESTTOT,
LPRINT SPC(2);"TONNES"
LPRINT "INITIAL COAL STOCK LEVEL",
LPRINT USING "########";CSLI,
LPRINT SPC(2);"TONNES"
LPRINT CHR$(12);
RETURN


SUB GAUSS(S,AMEAN,V) STATIC
A = 0
FOR I1 = 1 TO 12
RANDOMIZE TIMER
R = RND
A = A + R
```

```
NEXT I1
V = (A-6.0)*S + AMEAN
END SUB
```

```
DEFINT I - N
COMMON ITERATION,RUNN,IIIDE(2)
COMMON NAAS(2),IT(2)
COMMON DMM(1),DSS(1),CC(1),ATE(1),ICHUL(1),ISOURCE(1),ISCAT(1)
COMMON NNTOT,NHRTH,ITBER,NHRET,CSLI
COMMON IULA,AMTTFA,FDEVA,AMTTRA,REPDEVA
COMMON IULB,AMTTFB,FDEVB,AMTTRB,REPDEVB
COMMON IULC,AMTTFC,FDEVC,AMTTRC,REPDEVC
COMMON NXX,L
COMMON ILAYTIME(1)
COMMON ISAD(1),ISAH(1)

DIM IARR(5),DS(60),DM(60), IWAIT(60)
DIM CS(365),CU(365)
DIM NDC(60), NHC(60), NDV(60), NHV(60), NDVV(60), NHVV(60),NDB(60),NHB(60)
DIM NORN(60),NORH(60),DEFECTA(60),DEFECTB(60),DEFECTC(60),TYPHOON(60)

REM $DYNAMIC
DIM NB(365,24),NSHIP(365,24)
DIM NQ1(365,24),NQ2(365,24), NQ3(365,24),NQ4(365,24), NQ5(365,24),NQ6(365,24)
DIM IAOUT(365,24),IBOUT(365,24),ICOUT(365,24)

GOSUB INITUNLOADER

REM START OF QUEUING
PRINT "QUEUEING STARTED "
FOR NDUM = 1 TO 365
PRINT "." ;
FOR IHDUM = 1 TO 24
N = NDUM
IH = IHDUM

REM IF THERE IS AN ARRIVAL ?
IF NAAS(N,IH) = 0 THEN GOTO 420
GOSUB ASSIGNNOR

REM QUEUE ARRANGEMENT
380     GOSUB ARRQUEUE

REM CHECK IF ANY SHIP IN THE QUEUE
420     IF NQ1(N,IH) =< 0 THEN GOTO 440

REM CHECK IF BERTH OCCUPIED OR DESIGNATED TO A SHIP
IF NSHIP(N,IH) >0 THEN GOTO 435

REM DESIGNATE FIRST SHIP IN QUEUE TO BERTH
NN = NQ1(N,IH)
NDB(NN) = N
NHB(NN) = IH
DEFECTA(NN) = 0
DEFECTB(NN) = 0
DEFECTC(NN) = 0
TYPHOON(NN) = 0

REM REARRANGE QUEUE AFTER COMMITTED FIRST TO BERTH
NQ1(N,IH) = NQ2(N,IH)
NQ2(N,IH) = NQ3(N,IH)
NQ3(N,IH) = NQ4(N,IH)
NQ4(N,IH) = NQ5(N,IH)
```

```
      NQ5(N,IH) = NQ6(N,IH)
      NQ6(N,IH) = 0

      REM GO TO BERTHING AND UNLOADING PROGRAM
      GOSUB UNLOAD

      REM ALLOCATE BERTH OCCUPANCY HOURS
      GOSUB BERTHOCC

      REM ALLOCATE DESIGNATE SHIP QUEUE HOURS AND DEFECT HOURS
      GOSUB QUEUETIME

      REM INSPECTION OF UNLOADING EQUIPMENT AFTER SHIPMENT
      GOSUB INSPECT

      REM CARRY QUEUE TO NEXT HOUR
435   NNXT = NDUM
      IHNXT = IHDUM +1
      IF IHNXT =< 24 THEN GOTO 438
      IHNXT = IHNXT - 24
      NNXT = NNXT + 1
      IF NNXT > 365 THEN GOTO 440
438   NQ1(NNXT,IHNXT) = NQ1(NDUM,IHDUM)
      NQ2(NNXT,IHNXT) = NQ2(NDUM,IHDUM)
      NQ3(NNXT,IHNXT) = NQ3(NDUM,IHDUM)
      NQ4(NNXT,IHNXT) = NQ4(NDUM,IHDUM)
      NQ5(NNXT,IHNXT) = NQ5(NDUM,IHDUM)
      NQ6(NNXT,IHNXT) = NQ6(NDUM,IHDUM)
440   NEXT IHDUM
      NEXT NDUM

      REM GO TO OUTPUT SUBROUTINE
      GOSUB DOUTPUT

      RUNN = RUNN + 1
      PRINT "END OF RUN NUMBER ";RUNN
470   END

      INITUNLOADER :
      REM INITIALIZE UNLOADER STATISTICS

20    CALL GAUSS (REPDEVA, AMTTRA, VTTRA)
      IF VTTRA < 0 THEN GOTO 20
30    CALL GAUSS (FDEVA, AMTTFA, VTTFA)
      IF VTTFA < 0 THEN GOTO 30
      TTRA = VTTRA
      TTFA = VTTFA
      REM LPRINT "INIT TTFA " ; TTFA
      REM LPRINT "INIT TTRA " ; TTRA

40    CALL GAUSS (REPDEVB, AMTTRB, VTTRB)
      IF VTTRB < 0 THEN GOTO 40
50    CALL GAUSS (FDEVB, AMTTFB, VTTFB)
      IF VTTFB < 0 THEN GOTO 50
      TTRB = VTTRB
      TTFB = VTTFB
      REM LPRINT "INIT TTFB " ; TTFB
      REM LPRINT "INIT TTRB " ; TTRB

60    CALL GAUSS (REPDEVC, AMTTRC, VTTRC)
```

```
        IF VTTRC < 0 THEN GOTO 60
70      CALL GAUSS (FDEVC, AMTTFC, VTTFC)
        IF VTTFC < 0 THEN GOTO 70
        TTRC = VTTRC
        TTFC = VTTFC
        REM LPRINT "INIT TTFC " ; TTFC
        REM LPRINT "INIT TTRB " ; TTRB

        RANDOMIZE TIMER
        IRUNA = INT(RND * TTFA)
        IRUNB = INT(RND * TTFB)
        IRUNC = INT(RND * TTFC)

        SUMADOWN = 0 : SUMBDOWN = 0 : SUMCDOWN = 0
        SUMWAIT = 0

        RETURN

        ARRQUEUE :
        REM ARRANGE INTO QUEUE WITH QUEUE JUMPING
        ISQ =ISOURCE(NAAS(N,IH))
        ISQ1=ISOURCE(NQ1(N,IH))
        ISQ2=ISOURCE(NQ2(N,IH))
        ISQ3=ISOURCE(NQ3(N,IH))
        ISQ4=ISOURCE(NQ4(N,IH))
        ISQ5=ISOURCE(NQ5(N,IH))
        ISQ6=ISOURCE(NQ6(N,IH))
        TEMP = 0
        IF NQ1(N,IH) = 0 THEN
                NQ1(N,IH) = NAAS(N,IH)
        ELSEIF ISQ1 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NQ5(N,IH):NQ5(N,IH)=NQ4(N,IH):NQ4(N,IH)=NQ3(N,IH): _
                NQ3(N,IH)=NQ2(N,IH):NQ2(N,IH)=NQ1(N,IH):NQ1(N,IH)=NAAS(N,IH)
        ELSEIF NQ2(N,IH) = 0 THEN
                NQ2(N,IH) = NAAS(N,IH)
        ELSEIF ISQ2 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NQ5(N,IH):NQ5(N,IH)=NQ4(N,IH):NQ4(N,IH)=NQ3(N,IH): _
                NQ3(N,IH)=NQ2(N,IH):NQ2(N,IH)=NAAS(N,IH)
        ELSEIF NQ3(N,IH) = 0 THEN
                NQ3(N,IH) = NAAS(N,IH)
        ELSEIF ISQ3 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NQ5(N,IH):NQ5(N,IH)=NQ4(N,IH):NQ4(N,IH)=NQ3(N,IH): _
                NQ3(N,IH)=NAAS(N,IH)
        ELSEIF NQ4(N,IH) = 0 THEN
                NQ4(N,IH) = NAAS(N,IH)
        ELSEIF ISQ4 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NQ5(N,IH):NQ5(N,IH)=NQ4(N,IH):NQ4(N,IH)=NAAS(N,IH)
        ELSEIF NQ5(N,IH) = 0 THEN
                NQ5(N,IH) = NAAS(N,IH)
        ELSEIF ISQ5 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NQ5(N,IH):NQ5(N,IH)=NAAS(N,IH)
        ELSEIF NQ6(N,IH) = 0 THEN
                NQ6(N,IH) = NAAS(N,IH)
        ELSEIF ISQ6 = 1 AND ISQ > 1 THEN
                TEMP=NQ6(N,IH):NQ6(N,IH)=NAAS(N,IH)
        ELSE LPRINT "QUEUE OVERFLOW " : BEEP : BEEP :END
        END IF
        IF TEMP > 0 THEN PRINT "QUEUE OVERFLOW ! " : BEEP : BEEP : END
        RETURN
```

```
        UNLOAD :
        NOR = 0
        NUH = 0
        NTU = 0
        CCU = 0
        NVT = ISCAT(NN)

        REM CHECK IF NOR SUBMITTED
475     IF NORM(NN) = 365 AND NORH(NN) = 24 THEN NDC(NN) = 365 : NHC(NN) = 24 : _
             NDV(NN) = 365 : NHV(NN) = 24 : NDVV(NN) = 365 : NHVV(NN) = 24 : RETURN
        IF N*24 + IH >= NORM(NN)*24 + NORH(NN) THEN GOTO 480
        IH = IH + 1
        IF IH > 24 THEN IH = IH -24 : N = N + 1
        GOTO 475

480     NDC(NN) = N
        NHC(NN) = IH

        REM CHECK IF TYPHOON CONDITION SATISFIED
500     IF IT(N,IH) = 0 THEN GOTO 560
        REM TYPHOON, SHIP MOVE OUT TO OPEN SEA
        IK = 0
        REM LPRINT N;" " ; IH; "TYPHOON OUT TO OPEN SEA" ; IK
        IK = 1
        IH = IH + 1
510     IF IH =< 24 THEN GOTO 530
        IH = IH - 24
        N = N + 1
        GOTO 510
        IF N > 365 THEN GOTO 800

        REM CONTIUE CHECKING FOR TYPHOON
530     IF IT(N,IH) = 0 THEN GOTO 540
        IF IK < NHRET THEN IK = IK + 1
        IH = IH + 1
        REM LPRINT N;" " ; IH; "TYPHOON WAIT IN OPEN SEA" ; IK
        GOTO 510

        REM TYPHOON SIGNAL LOWERED RETURN FROM SEA
540     REM LPRINT N; " " ; IH; "SIGNAL LOWERED RETURN START"; IK
        IH = IH + IK
550     IF IH =< 24 THEN GOTO 560
        IH = IH - 24
        N = N + 1
        GOTO 550
        IF N > 365 THEN GOTO 800
        REM LPRINT N; " " ; IH; " RETURNED TO LOCAL WATERS"
        GOTO 560
555     IH = IH +1
557     IF IH =< 24 THEN GOTO 558
        IH = IH - 24
        N = N + 1
        GOTO 557
558     IF N > 365 THEN GOTO 800
        REM CHECK FOR TIDE AND DAYLIGHT
```

```
560     IHHH = IH + ITBER
        NNN = N
565     IF IHHH =< 24 THEN GOTO 569
        NNN = NNN + 1
        IHHH = IHHH -24
        GOTO 565
569     IF NNN - 365 > 0 THEN GOTO 800
        IF ITIDE (NNN, IHHH) <> 1 THEN GOTO 555
        IF IHHH < 6  THEN GOTO 555
        IF IHHH > 18 THEN GOTO 555

        REM CONDITION OK PROCEED TO BERTH
        REM LPRINT N; " " ; IH; "TIDE AND DAYLIGHT OK PROCEED TO BERTH"
        IB = 0
580     IH = IH + 1
        IB = IB + 1
570     IF IH =< 24 THEN GOTO 575
        IH = IH -24
        N = N + 1
        GOTO 570
        IF N > 365 THEN GOTO 800

        REM CHECK TYPHOON AGAIN
575     IF IT(N,IH) = 0 AND IB = ITBER THEN GOTO 620
        IF IT(N,IH) = 0 AND IB < ITBER THEN GOTO 580

        REM CHECK IF VESSEL REACHED JETTY
        IF IB = ITBER THEN GOTO 585

        REM VESSEL HAS NOT REACHED JETTY SEND IT AWAY
        REM LPRINT N; " "; IH; " TYPHOON VESSEL HLF WAY TO JETTY"
        IH = IH + IB
        IF IH <= 24 THEN GOTO 582
        IH = IH -24
        N = N + 1
582     IF N > 365 THEN GOTO 800
        GOTO 500

        REM TYPHOON HOISTED CHECK IF VESSEL TIED UP
585     IF NTU > 0 GOTO 615

        REM TYPHOON VESSEL NOT TIED UP TO BE TOWED OUT
        IF IH < 6 THEN GOTO 598
        IF IH >18 THEN GOTO 598
        REM LPRINT N; " " ; IH; " CONDITION OK TOW OUT"
        IH = IH + ITBER
        IF IH = < 24 THEN GOTO 590
        N = N + 1
        IH = IH - 24
590     IF N > 365 THEN GOTO 800
        GOTO 500
598     REM LPRINT N; " " ; IH ; "DAY LIGHT NOT OK WAIT FOR 1 HR"
600     IH = IH + 1
        IF IH =< 24 THEN GOTO 610
        N = N + 1
        IH = IH -24
610     IF N > 365 THEN GOTO 800
        GOTO 575
615     REM LPRINT N; " " ; IH; " UNTIE VESSEL BY ONE HOUR" : NTU = NTU -1
        GOTO 600
```

```
    REM CHECK IF VESSEL TIED UP
620 IF NTU = NVBTH THEN GOTO 630
    REM LPRINT N; " "; IH; " TIE UP VESSEL BY ONE HOUR
    NTU = NTU +1
    GOTO 600

630 REM CAL UNLOADER BREAKDOWNS
    GOSUB BREAKDOWN
    REM USE DIFF UNLOADING RATE FOR DIFF STAGES OF UNLOADING
    IF CCU < 0.3*ATE(NVT) THEN_
    IULAAA = IULAA : IULBBB = IULBB : IULCCC = IULCC : GOTO 635
    IF CCU >= 0.3*ATE(NVT) AND CCU <= 0.7*ATE(NVT) THEN_
    IULAAA = 0.7*IULAA : IULBBB = 0.7*IULBB : IULCCC = 0.7*IULCC : GOTO 635
    IULAAA =  0.4*IULAA : ILBBB = 0.4*IULBB : IULCCC = 0.4*IULCC
635 IULDR = IULAAA + IULBBB + IULCCC
    IF (ATE(NVT)-CCU-IULDR) < 0 THEN GOTO 640
    CU(N) = IULDR + CU(N)
    CCU = CCU + IULDR
    REM LPRINT N; IH; "UNLOADED FOR 1 HOUR";"SHIP "; NN;"COAL UNLOADED CUM";_
    CCU; "COAL UNLOADED DAY";CU(N)
    GOTO 650
640 CU(N) = ATE(NVT) - CCU + CU(N)
    CCU = ATE(NVT)
    REM LPRINT N; " " ; IH; " UNLOADING FINISHED" ; CCU; CU(N)
650 NUH = NUH + 1

    REM CHECK UNLOADING FINISHED
    IF ATE(NVT) > CCU THEN GOTO 600
    NDVV(NN) = N
    NHVV(NN) = IH
655 IF IH < 6  THEN GOTO 900
    IF IH > 18 THEN GOTO 900
    IH = IH + NTU
    IF IH <= 24 THEN GOTO 660
    IH = IH - 24
    N = N + 1
660 IF N > 365 THEN GOTO 800
    NDV(NN) = N
    NHV(NN) = IH
    GOTO 801

800 REM ADJUST LAST DAY ENTRY
    NDVV(NN) = 365
    NHVV(NN) = 24
    NDV(NN) = 365
    NHV(NN) = 24

801 REM LPRINT N; " " ; IH; " BERTH VACATED"
    N = NDUM
    IH = IHDUM
    RETURN

900 REM LPRINT N; " " ; IH; " DAYLIGHT NOT OK WAIT"
    IH = IH + 1
    IF IH <= 24 THEN GOTO 910
    IH = IH - 24
    N = N + 1
910 IF N > 365 THEN GOTO 800
    GOTO 655
```

```
        BREAKDOWN :

        REM ALLOCATE MAINTENANCE DOWN TIME FOR UNLOADER A
        IF IRUNA >= TTFA THEN GOTO 1010
        IF IAOUT(N,IH) = 1 THEN GOTO 1080
        IULAA = IULA
        IRUNA = IRUNA + 1
        GOTO 1200

1010    IBH = IH + TTRA - 1
        IBN = N
1020    IF IBH =<24 THEN GOTO  1030
        IBH = IBH-24
        IBN = IBN + 1
        GOTO1020
1030    IF IBN =< 365 THEN GOTO 1040
        IBN = 365
        IBH = 24

1040    ND1 = N
        ND2 = IBN
        ND3 = IH
        ND4 = IBH
        IF ND1 <> ND2 THEN GOTO 1045
        FOR MMM = ND3 TO ND4
                IAOUT(ND1,MMM)=1
        NEXT MMM
        GOTO 1075
1045    FOR MM = ND1 TO ND2
                IF MM - N > 0 THEN GOTO 1050
                        FOR MMM = ND3 TO 24
                        IAOUT(MM,MMM) = 1
                        NEXT MMM
                        GOTO 1070
1050            IF IBN - MM = 0 THEN GOTO 1060
                        FOR MMM = 1 TO 24
                        IAOUT(MM,MMM) = 1
                        NEXT MMM
                        GOTO 1070
1060             FOR MMM = 1 TO ND4
                        IAOUT(MM,MMM) = 1
                NEXT MMM
1070     NEXT MM

        REM TO REGEN TTR AND TTF DATA HERE
1075    CALL GAUSS (REPDEVA, AMTTRA, VTTRA)
        IF VTTRA < 0 THEN GOTO 1075
1077    CALL GAUSS (FDEVA, AMTTFA, VTTFA)
        IF VTTFA < 0 THEN GOTO 1077
        TTRA = VTTRA
        TTFA = VTTFA

        REM RESET RUNNING HOURS TO ZERO
1080    IRUNA = 0
        IULAA = 0
        REM LPRINT "                    UNLOADER A UNDER REPAIR " ; _
        "DAY " ; N ; "HOUR " IH
        GOTO 1200
```

```
1200   REM SAME FOR UNLOADER B

       REM ALLOCATE MAINTENANCE DOWN TIME FOR UNLOADER B
       IF IRUNB >= TTFB THEN GOTO 2010
       IF IBOUT(N,IH) = 1 THEN GOTO 2080
       IULBB = IULB
       IRUNB = IRUNB + 1
       GOTO 2200

2010   IDH = IH + TTRB - 1
       IDN = N
2020   IF IBH =<24 THEN GOTO  2030
       IDH = IBH-24
       IDN = IBN + 1
       GOTO 2020
2030   IF IDN =< 365 THEN GOTO 2040
       IBN = 365
       IBH = 24

2040   ND1 = N
       ND2= IBN
       ND3 = IH
       ND4 = IBH
       IF ND1 <> ND2 THEN GOTO 2045
       FOR MMM = ND3 TO ND4
               IBOUT(ND1,MMM)=1
       NEXT MMM
       GOTO 2075
2045   FOR MM = ND1 TO ND2
               IF MM - N > 0 THEN GOTO 2050
                       FOR MMM = ND3 TO 24
                       IBOUT(MM,MMM) = 1
                       NEXT MMM
                       GOTO 2070
2050           IF IBN - MM = 0 THEN GOTO 2060
                       FOR MMM = 1 TO 24
                       IBOUT(MM,MMM) = 1
                       NEXT MMM
                       GOTO 2070
2060            FOR MMM = 1 TO ND4
                       IBOUT(MM,MMM) = 1
               NEXT MMM
2070    NEXT MM

       REM TO REGEN TTR AND TTF DATA HERE
2075   CALL GAUSS (REPDEVB, AMTTRB, VTTRB)
       IF VTTRB < 0 THEN GOTO 2075
2077   CALL GAUSS (FDEVB, AMTTFB, VTTFB)
       IF VTTFB < 0 THEN GOTO 2077
       TTRB = VTTRB
       TTFB = VTTFB

       REM RESET RUNNING HOURS TO ZERO
2080   IRUNB = 0
       IULBB = 0
       REM LPRINT "                    UNLOADER B UNDER REPAIR " ; _
       "DAY "; N ; " HOUR " ; IH
       GOTO 2200
```

```
2200    REM SAME FOR UNLOADER C
        IF IULC = 0 THEN GOTO 4000
        REM ALLOCATE MAINTENANCE DOWN TIME FOR UNLOADER C
        IF IRUNC >= TTFC THEN GOTO 3010
        IF ICOUT(N,IH) = 1 THEN GOTO 3080
        IULCC = IULC
        IRUNC = IRUNC + 1
        GOTO 4000

3010    IBH = IH + TTRC - 1
        IBN = N
3020    IF IBH =<24 THEN GOTO  3030
        IBH = IBH-24
        IBN = IBN + 1
        GOTO 3020
3030    IF IBN =< 365 THEN GOTO 3040
        IBN = 365
        IBH = 24

3040    ND1 = N
        ND2 = IBN
        ND3 = IH
        ND4 = IBH
        IF ND1 <> ND2 THEN GOTO 3045
        FOR MMM = ND3 TO ND4
                ICOUT(ND1,MMM)=1
        NEXT MMM
       GOTO 3075
3045    FOR MM = ND1 TO ND2
                IF MM - N > 0 THEN GOTO 3050
                        FOR MMM = ND3 TO 24
                        ICOUT(MM,MMM) = 1
                        NEXT MMM
                        GOTO 3070
3050            IF IBN - MM = 0 THEN GOTO 3060
                        FOR MMM = 1 TO 24
                        ICOUT(MM,MMM) = 1
                        NEXT MMM
                        GOTO 3070
3060             FOR MMM = 1 TO ND4
                        ICOUT(MM,MMM) = 1
                NEXT MMM
3070     NEXT MM

        REM TO RESEN TTR AND TTF DATA HERE
3075    CALL GAUSS (REPDEVC, AMTTRC, VTTRC)
        IF VTTRC < 0 THEN GOTO 3075
3077    CALL GAUSS (FDEVC, AMTTFC, VTTFC)
        IF VTTFC < 0 THEN GOTO 3077
        TTRC = VTTRC
        TTFC = VTTFC

        REM RESET RUNNING HOURS TO ZERO
3080    IRUNC = 0
        IULCC = 0
        REM LPRINT "                    UNLOADER C UNDER REPAIR " ; _
        "DAY "; N ; " HOUR " ; IH
        GOTO 4000
```

```
4000   REM CALCULATE TOTAL UNLOADER DOWN TIME

       SUMADOWN = SUMADOWN + IAOUT(N,IH)
       SUMBDOWN = SUMBDOWN + IBOUT(N,IH)
       SUMCDOWN = SUMCDOWN + ICOUT(N,IH)

       RETURN

       BERTHOCC :
       ND1 = NDC(NN)
       ND2 = NDV(NN)
       ND3 = NHC(NN)
       ND4 = NHV(NN)
       FOR N = ND1 TO ND2
            IF N - NDC(NN) > 0 THEN GOTO 425
                 FOR IH = ND3 TO 24
                 NB(N,IH) = NN
                 NEXT IH
                 GOTO 430
425         IF NDV(NN) - N = 0 THEN GOTO 427
                 FOR IH = 1 TO 24
                 NB(N,IH) = NN
                 NEXT IH
                 GOTO 430
427         FOR IH = 1 TO ND4
            NB(N,IH) = NN
            NEXT IH
430    NEXT N
       RETURN

       QUEUETIME :
       REM ALLOCATE DESIGNATED SHIP QUEUE HOURS AND DEFECT HOURS
       REM CHECK IF ANY ARRIVAL SINCE DESIGNATED TO BERTH
       ND1 = NDB(NN)
       ND2 = NDV(NN)
       ND3 = NHB(NN)
       ND4 = NHV(NN)
       ARRFLAG = 0
       FOR N = ND1 TO ND2
            IF N - NDB(NN) > 0 THEN GOTO 455
                 FOR IH = ND3 TO 24
                 IF IAOUT(N,IH) > 0 THEN DEFECTA(NN) = DEFECTA(NN) + 1
                 IF IBOUT(N,IH) > 0 THEN DEFECTB(NN) = DEFECTB(NN) + 1
                 IF ICOUT(N,IH) > 0 THEN DEFECTC(NN) = DEFECTC(NN) + 1
                 IF IT(N,IH) > 0 THEN TYPHOON(NN) = TYPHOON(NN) + 1
                 IF IH = ND3 THEN GOTO 454
                 IF NAAS(N,IH) > 0 THEN ARRFLAG = 1
454              NSHIP(N,IH) = NN
                 NEXT IH
                 GOTO 460
455         IF NDV(NN) - N = 0 THEN GOTO 457
                 FOR IH = 1 TO 24
                 IF IAOUT(N,IH) > 0 THEN DEFECTA(NN) = DEFECTA(NN) + 1
                 IF IBOUT(N,IH) > 0 THEN DEFECTB(NN) = DEFECTB(NN) + 1
                 IF ICOUT(N,IH) > 0 THEN DEFECTC(NN) = DEFECTC(NN) + 1
                 IF IT(N,IH) > 0 THEN TYPHOON(NN) = TYPHOON(NN) + 1
                 IF NAAS(N,IH) > 0 THEN ARRFLAG = 1
                 NSHIP(N,IH) = NN
                 NEXT IH
                 GOTO 460
```

```
457       FOR IH = 1 TO ND4
              IF IAOUT(N,IH) > 0 THEN DEFECTA(NN) = DEFECTA(NN) + 1
               IF IBOUT(N,IH) > 0 THEN DEFECTB(NN) = DEFECTB(NN) + 1
               IF ICOUT(N,IH) > 0 THEN DEFECTC(NN) = DEFECTC(NN) + 1
               IF IT(N,IH) > 0 THEN TYPHOON(NN) = TYPHOON(NN) + 1
               IF NAAS(N,IH) > 0 THEN ARRFLAG = 1
              NSHIP(N,IH) = NN
          NEXT IH
460   NEXT N

      REM REGISTER WAITING TIME
      IWAIT(NN) = (NDC(NN)*24 + NHC(NN)) - (NORN(NN)*24 + NORH(NN))
      IF NDC(NN) = 0 THEN IWAIT(NN) = 0
      SUMWAIT = SUMWAIT + IWAIT(NN)
      RETURN

      INSPECT :

      IF NO1(NDB(NN),NHB(NN)) > 0 THEN  : RETURN
      IF ARRFLAG = 1 THEN : RETURN
      IF NHV(NN)  <= 8 THEN NNDV = NDV(NN)  ELSE NNDV = NDV(NN) + 1
      IF NNDV > 365 THEN NNDV = 365
      IF NDV(NN) < NNDV THEN GOTO 5120
      N = NDV(NN)
      FOR IH = NHV(NN) TO 20
      IF NAAS(N,IH) > 0 THEN RETURN
      NEXT IH
      GOTO 5150
5120  FOR N = NDV(NN) TO NNDV
      IF N > NDV(NN) THEN GOTO 5130
      FOR IH = NHV(NN) TO 24
      IF NAAS(N,IH) > 0 THEN RETURN
      NEXT IH
      GOTO 5140
5130  FOR IH = 1 TO 20
      IF NAAS(N,IH) > 0 THEN RETURN
      NEXT IH
5140  NEXT N
5150  IF IRUNA < 0.9*TTFA THEN GOTO 5180
5160  CALL GAUSS (FDEVA,AMTTFA,VTTFA)
      IF VTTFA < 0 THEN GOTO 5160
      TTFA = VTTFA
      IRUNA = 0
5180  IF IRUNB < 0.9*TTFB THEN GOTO 5200
5190  CALL GAUSS (FDEVB,AMTTFB,VTTFB)
      IF VTTFB < 0 THEN GOTO 5190
      TTFB = VTTFB
      IRUNB = 0

5200  IF IRUNC < 0.9*TTFC THEN GOTO 5230
5210  CALL GAUSS (FDEVC,AMTTFC,VTTFC)
      IF VTTFC < 0 THEN GOTO 5210
      TTFC = VTTFC
      IRUNC = 0

5230  RETURN

      DOUTPUT :
      REM CALCULATE COAL STOCK
```

```
        CDH = 0 : CS0 = 0 : CS1 = 0 : CS2 = 0 : CS3 = 0 : CS4 = 0
        CS5 = 0 : CS6 = 0
        IF CU(1) <= CC(1) THEN GOTO 5010
        CDH = CU(1) - CC(1)
5010    CCT = CC(1)
        CUT = CU(1)
        CS(1) = CSLT + CU(1) - CC(1)
        FOR N = 2 TO 365
        NP = N-1
        CS(N) = CS(NP) + CU(N) - CC(N)
        IF CS(N) < 0 THEN CS(N) = 0 : CC(N) = CS(NP) + CU(N)
        CUT = CUT + CU(N)
        CCT = CCT + CC(N)
        IF CS(N) = 0 THEN CS0 = CS0 + 1
        IF CS(N) < 50000 THEN CS1 = CS1 + 1
        IF CS(N) < 100000 THEN CS2 = CS2 + 1
        IF CS(N) < 150000 THEN CS3 = CS3 + 1
        IF CS(N) < 200000 THEN CS4 = CS4 + 1
        IF CS(N) > 299000 THEN CS5 = CS5 + 1
        IF CS(N) > 456000 THEN CS6 = CS6 + 1
        IF CU(N) =< CC(N) THEN GOTO 5030
        CDH = CDH + CU(N) - CC(N)

5030    NEXT N

        REM CAL DESPATCH/DEMURAGE
        DMT = 0
        DST = 0
        IBOC = 0
        FOR NN = 1 TO NNTOT
        NVT = ISCAT(NN)
        IBOC = IBOC + NHV(NN) - NHC(NN) + (NDV(NN) - NDC(NN)) * 24
        REM CHINESE COAL SHIPS HAVE NO DEM/DES
        IF ISOURCE(NN) = 1 THEN GOTO 5050
        IF NORN(NN) = 0 OR NDC(NN) = 0 THEN GOTO 5050
        IF NDVV(NN) = 365 AND NHVV(NN) = 24 THEN GOTO 5050
        IAAA = ICHUL(NVT)-(NHVV(NN)-NORH(NN)+(NDVV(NN)-NORN(NN))*24-TYPHOON(NN))
        IF IAAA = 0 THEN GOTO 5050
        IF IAAA > 0 THEN GOTO 5040
        DMT = DMT - IAAA * DMM(NVT)
        DM(NN) = 0 - IAAA
        DS(NN) = 0
        GOTO 5060
5040    DST = DST + IAAA * DSS(NVT)
        DS(NN) = IAAA
        DM(NN) = 0
        GOTO 5060
5050    DM(NN) = 0
        DS(NN) = 0
5060    NEXT NN
        BOC = IBOC * 100.0 /(365 * 24)
        DMD = DMT - DST

        BEEP : PRINT
        PRINT "PRINTER READY? (Y/N) " : INPUT X$
        IF LEFT$ (X$,1) = "Y" THEN GOTO 6010
        RETURN
6010    WIDTH "LPT1:", 137
        LPRINT CHR$(15);
        LPRINT CHR$(27);"C";CHR$(66);
```

```
      LPRINT CHR$(27);"N";CHR$(6);
      LPRINT CHR$(27);"O";CHR$(137);
8887  INPUT "WANT TO BYPASS THE 365 DAYS PRINTOUT ? (Y/N)", ZZ$
      IF ZZ$ = "Y" THEN GOTO 8890
      IF ZZ$ <> "N" THEN GOTO 8887
      LPRINT "DAY",,"      TYPHOON   " + "UNLOADER OUTAGE    BERTH","MAXIMUN","COAL","COAL","STOCK"
      LPRINT "NO.";"       ARRIVALS"," SIGNAL   " + "  1   2   3 ", "OCCUPANCY","QUEUE",_
      "UNLOADED","CONSUMPTION","LEVEL"
      LPRINT
      NB1 = 0
      NB2 = 0
      ISD = 0
8888  FOR N = 1 TO 365
          NOMAX = 0
          TY$ = " "
          FOR IH = 1 TO 24
              IF NO1(N,IH) > 0 THEN GOTO 6020
              NOOO = 0
              GOTO 6070
6020          IF NO2(N,IH) > 0 THEN GOTO 6030
              NOOO = 1
              GOTO 6070
6030          IF NO3(N,IH) > 0 THEN GOTO 6040
              NOOO = 2
              GOTO 6070
6040          IF NO4(N,IH) > 0 THEN GOTO 6050
              NOOO = 3
              GOTO 6070
6050          IF NO5(N,IH) > 0 THEN GOTO 6060
              NOOO = 4
              GOTO 6070
6060          IF NO6(N,IH) > 0 THEN GOTO 6065
              NOOO = 5
              GOTO 6070
6065          NOOO = 6
6070          IF NOMAX > NOOO THEN GOTO 6080
              NOMAX = NOOO
6080          NEXT IH
      FOR I = 1 TO 5
      IARR(I) = 0
      NEXT I
      I = 1
      IF NB1 > 0 THEN GOTO 6110
      IF NB2 > 0 THEN GOTO 6150
      ISD = 0
      GOTO 6150
6110  IF NB2 = 0 THEN GOTO 6150
      IF ISD > 0 THEN GOTO 6130
      ISD = 1
      GOTO 6150
6130  ISD = 0
6150  NB1 = 0
      NB2 = 0
      ADOWN = 0 : BDOWN = 0 : CDOWN = 0
      REM ARRANGE PRINT SEQUENCE OF UNLOADING VESSELS
      FOR IH = 1 TO 24
      IF NB(N,IH) =0 THEN GOTO 6290
      IF ISD > 0 THEN GOTO 6250
      IF (NB1 + NB2) > 0 THEN GOTO 6210
```

```
6205    NB1 = NB(N,IH)
        GOTO 6290
6210    IF B(N,IH) = NB1 THEN GOTO 6205
        NB2 = NB(N,IH)
        GOTO 6290
6250    IF (NB1 +NB2) > 0 THEN GOTO 6270
6260    NB2 = NB(N,IH)
        GOTO 6290
6270    IF NB(N,IH) = NB2 THEN GOTO 6260
        GOTO 6205
6290    IF NAAS(N,IH) = 0 THEN GOTO 6310
        IARR(I) = NAAS(N,IH)
        I = I+1
6310    IF IT(N,IH) = 0 THEN GOTO 6320
        TY$ = "T"
6320    ADOWN = ADOWN + IAOUT(N,IH)
        BDOWN = BDOWN + IBOUT(N,IH)
        CDOWN = CDOWN + ICOUT(N,IH)
        NEXT IH

        A$ = STR$(IARR(1)) : B$ = STR$(IARR(2))
        C$ = STR$(IARR(3)) : D$ = STR$(IARR(4))
        E$ = STR$(IARR(5))
        LENA = LEN(A$) : LENB = LEN(B$) : LENC = LEN(C$)
        LEND = LEN(D$) : LENE = LEN(E$)
        IF LENA = 2 THEN PA$ = "  " ELSE PA$ = " "
        IF VAL(A$) = 0 THEN A$ = "" : PA$ = "    "
        IF LENB = 2 THEN PB$ = "  " ELSE PB$ = " "
        IF VAL(B$) = 0 THEN B$ = "" : PB$ = "    "
        IF LENC = 2 THEN PC$ = "  " ELSE PC$ = " "
        IF VAL(C$) = 0 THEN C$ = "" : PC$ = "    "
        IF LEND = 2 THEN PD$ = "  " ELSE PD$ = " "
        IF VAL(D$) = 0 THEN D$ = "" : PD$ = "    "
        IF LENE = 2 THEN PE$ = "  " ELSE PE$ = " ".
        IF VAL(E$) = 0 THEN E$ = "" : PE$ = "    "
        ARRIVAL$ = PA$ + A$ + PB$ + B$ + PC$ + C$ + PD$ + D$ + PE$ + E$
        F$ = STR$(NB1) : G$ = STR$(NB2)
        LENF = LEN(F$) : LENG = LEN(G$)
        IF LENF = 2 THEN PF$ = " " ELSE PF$ = ""
        IF VAL(F$) = 0 THEN F$ = "" : PF$ = "   "
        IF LENG = 2 THEN PG$ = "  " ELSE PG$ = " "
        IF VAL(G$) = 0 THEN G$ = "" : PG$ = "    "
        BERTH$ = PF$ + F$ + PG$ + G$
        IF TY$ = "T" THEN T$ = TY$ ELSE T$ = " "
        IF NOMAX=0 THEN Q$= " " ELSE Q$ = STR$(NOMAX)
        N$ = STR$(N) : LENN = LEN(N$)
        NO$ = SPACE$(4 - LENN) + N$
        IF ADOWN = 0 THEN DA$ = "" ELSE DA$ = STR$(ADOWN)
        IF BDOWN = 0 THEN DB$ = "" ELSE DB$ = STR$(BDOWN)
        IF DOWN = 0 THEN DC$ = "" ELSE DC$ = STR$(CDOWN)
        DAA$ = SPACE$(4 - LEN(DA$)) + DA$
        DBB$ = SPACE$(4 - LEN(DB$)) + DB$
        DCC$ = SPACE$(4 - LEN(DC$)) + DC$

        IF ZZ$ = "Y" THEN GOTO 8889
        LPRINT NO$; "  " + ARRIVAL$ + "    " + T$ + "      " + DAA$ + DBB$ + DCC$, BERTH$,"  " + Q$,
        LPRINT USING "######.#      ";CU(N);CC(N);CS(N)
8889    NEXT N
        IF ZZ$ = "Y" THEN GOTO 8890
        LPRINT CHR$(12);
```

```
8890    LPRINT "DEL. NO.    DAY(HOUR)      DAY(HOUR)     DAY(HOUR)    DESPATCH      DEMURRAGE _
        WAITING   INTERRUPTIONS"
        LPRINT "/SOURCE/CAT.    NOR         COMMITTED     RELEASED       (HRS)          (HRS)    _
        TIME (HRS) "
        LPRINT
        FOR NN = 1 TO NNTOT
        IF NORN(NN) > 0 THEN GOTO 6400
        LPRINT USING "### " ;NN ;
        LPRINT "/";
        LPRINT USING "## ";ISOURCE (NN);
        LPRINT "/";
        LPRINT USING " #    ";ISCAT(NN);
        LPRINT "NOT ARRIVED"
        GOTO 6440
6400    IF NDC(NN) > 0 THEN GOTO 6410
        LPRINT USING "### " ;NN ;
        LPRINT "/";
        LPRINT USING "## ";ISOURCE (NN);
        LPRINT "/";
        LPRINT USING " #    ";ISCAT(NN);
        LPRINT USING "###";NORN(NN);
        LPRINT "(";
        LPRINT USING "##";NORH(NN);
        LPRINT ")",
        LPRINT "NOT COMMITTED"
        GOTO 6440
6410    IF (NDVV(NN) = 365 AND NHVV(NN) = 24) THEN GOTO 6430
6420    LPRINT USING "### " ;NN ;
        LPRINT "/";
        LPRINT USING "## ";ISOURCE (NN);
        LPRINT "/";
        LPRINT USING " #    ";ISCAT(NN);
        LPRINT USING "###";NORN(NN);
        LPRINT "(";
        LPRINT USING "##";NORH(NN);
        LPRINT ")",
        LPRINT USING "###"; NDC(NN);
        LPRINT "(";
        LPRINT USING "##"; NHC(NN);
        LPRINT ")",
        LPRINT USING "###" ;NDV(NN);
        LPRINT "(";
        LPRINT USING "##"; NHV(NN);
        LPRINT ")",
        LPRINT USING " ####          ";DS(NN);DM(NN);
        LPRINT USING "  ###      ";IWAIT(NN);
        IF DEFECTA(NN) > 0 THEN LPRINT "D#1 ";DEFECTA(NN);"HRS  ";
        IF DEFECTB(NN) > 0 THEN LPRINT "D#2 ";DEFECTB(NN);"HRS  ";
        IF DEFECTC(NN) > 0 THEN LPRINT "D#3 ";DEFECTC(NN);"HRS  ";
        IF TYPHOON(NN) > 0 THEN LPRINT "T ";TYPHOON(NN);"HRS ";
        LPRINT
        GOTO 6440
6430    LPRINT USING "### " ;NN ;
        LPRINT "/";
        LPRINT USING "## ";ISOURCE (NN);
        LPRINT "/";
        LPRINT USING " #    ";ISCAT(NN);
        LPRINT USING "###";NORN(NN);
        LPRINT "(";
```

```
        LPRINT USING "##";NORH(NN);
        LPRINT ")",
        LPRINT USING "###"; NDC(NN);
        LPRINT "(";
        LPRINT USING "##"; NHC(NN);
        LPRINT ")",
        LPRINT "INCOMPLETE                    ";
        LPRINT USING "  ###       ";IWAIT(NN)
6440    NEXT NN

        NOMAXMAX = 0
        FOR N = 1 TO 365
            NOMAX = 0
            FOR IH = 1 TO 24
                IF NO1(N,IH) > 0 THEN GOTO 7020
                NOOO = 0
                GOTO 7070
7020            IF NO2(N,IH) > 0 THEN GOTO 7030
                NOOO = 1
                GOTO 7070
7030            IF NO3(N,IH) > 0 THEN GOTO 7040
                NOOO = 2
                GOTO 7070
7040            IF NO4(N,IH) > 0 THEN GOTO 7050
                NOOO = 3
                GOTO 7070
7050            IF NO5(N,IH) > 0 THEN GOTO 7060
                NOOO = 4
                GOTO 7070
7060            IF NO6(N,IH) > 0 THEN GOTO 7065
                NOOO = 5
                GOTO 7070
7065            NOOO = 6
7070            IF NOMAX > NOOO THEN GOTO 7080
                NOMAX = NOOO
7080        NEXT IH
        IF NOMAXMAX < NOMAX THEN NOMAXMAX = NOMAX
        NEXT N

        LPRINT
        LPRINT "TOTAL COAL CONSUMED        ", CCT, "TONNE"
        LPRINT "TOTAL COAL DOUBLE HANDLED", CDH, "TONNE"
        LPRINT "TOTAL COAL UNLOADED        ", CUT, "TONNE"
        LPRINT "BERTH OCCUPANCY            ", BOC, "%"
        LPRINT "TOTAL DEMURRAGE CHARGE     ", DMT, "US$"
        LPRINT "TOTAL DESPATCH VALUE       ", DST, "US$"
        LPRINT "NET PAY OUT                ", DMD, "US$"
        LPRINT "MAXIMUM QUEUE LENGTH       ", NOMAXMAX
        LPRINT "AVERAGE WAITING TIME       ", SUMWAIT/NNTOT, "HRS/SHIP"

        LPRINT "NO. OF DAYS COAL STOCK WENT ABOVE 456000 TONNS ",CS6,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK WENT ABOVE 299000 TONNES ",CS5,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK FELL BELOW 200000 TONNES ",CS4,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK FELL BELOW 150000 TONNES ",CS3,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK FELL BELOW 100000 TONNES ",CS2,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK FELL BELOW  50000 TONNES ",CS1,"DAYS"
        LPRINT "NO. OF DAYS COAL STOCK OUT                      ",CS0,"DAYS"

        LPRINT "NO. OF HOURS UNLOADER NO. 1 DOWN FOR DEFECT MAINTENANCE",SUMADOWN
        LPRINT "NO. OF HOURS UNLOADER NO. 2 DOWN FOR DEFECT MAINTENANCE",SUMBDOWN
```

```
LPRINT "NO. OF HOURS UNLOADER NO. 3 DOWN FOR DEFECT MAINTENANCE",SUMCDOWN
LPRINT "NO. OF TYPHOONS IN THE YEAR IS ";NXX;" AND TOTAL TYPHOON HOURS IS ";L
LPRINT CHR$(12);

OPEN "A", #1,"OUTPUT.DAT"
WRITE #1,CCT,CDH,CUT,BOC,DMT,DST,DMD,NOMAXMAX,SUMWAIT/NNTOT,_
CS6,CS5,CS4,CS3,CS2,CS1,CS0,SUMADOWN,SUMBDOWN,SUMCDOWN,NXX,L
CLOSE #1
RETURN



APPENDIX :
REM ASSIGN NOR DAY AND HOUR
PAD = ISAD(NN) -  ILAYTIME(NN)
IF ILAYTIME(NN) > = 0 THEN GOTO 9010
IF PAD - NDB(NN) > 0 THEN COUNTDAY = NDB(NN) : COUTHOUR = NHB(NN) : GOTO 9030
COUNTDAY = PAD
COUNTHOUR = 1
GOTO 9030
9010  IF ISCAT(NN) = 1 THEN DEADLINE =  4 : GOTO 9020
      IF ISCAT(NN) = 2 THEN DEADLINE =  9 : GOTO 9020
9020  IF ILAYTIME(NN) > DEADLINE THEN COUNTDAY = NDB(NN) : COUNTHOUR = NHB(NN) : GOTO 9030
      COUNTDAY = ISAD(NN)
      COUNTHOUR = ISAH(NN)
9030  NORN(NN) = COUNTDAY
      NORH(NN) = COUNTHOUR
111   IF NORH(NN) > 7 AND NORH(NN) < 17 AND IT(NORN(NN),NORH(NN)) = 0 THEN RETURN
      NORH(NN) = NORH(NN) + 1
      IF NORH(NN) > 24 THEN GOTO 222
      GOTO 111
222   NORH(NN) = NORH(NN) -24
      NORN(NN) = NORN(NN) + 1
      IF NORN(NN) > 365 THEN NORN(NN) = 365 : NORH(NN) = 24 : RETURN
      GOTO 111



SUB GAUSS(S,AMEAN,V) STATIC
A=0
FOR I1=1 TO 12
RANDOMIZE TIMER
R = RND
A = A + R
NEXT I1
V = (A-6.0)*S + AMEAN
END SUB

SUB NEGEXP(LAMDA,ALENGTH,X) STATIC
RANDOMIZE TIMER
R = RND
INTVAL = -LOG(1.0-R)/LAMDA
X = INTVAL*ALENGTH
END SUB

ASSIGNNOR :
NN=NAAS(N,IH)
NORN(NN) = N
NORH(NN) = IH
```

```
1111  IF NORH(NN) > 7 AND NORH(NN) < 17 AND IT(NORN(NN),NORH(NN)) = 0 THEN RETURN
      NORH(NN) = NORH(NN) + 1
      IF NORH(NN) > 24 THEN GOTO 2222
      GOTO 1111
2222  NORH(NN) = NORH(NN) -24
      NORN(NN) = NORN(NN) + 1
      IF NORN(NN) > 365 THEN NORN(NN) = 365 : NORH(NN) = 24 : RETURN
      GOTO 1111
```

Appendix 2 Sample Printouts

NUMBER OF SOURCE OF COAL USED 5

PLANNED ARRIVALS

SOURCE NO.	PLANNED ARRIVAL DAY	ACTUAL ARRIVAL DAY	VESSEL CATEGORY	DELAY : PLANNED -ACTUAL ARRIVAL MEAN	STD.DEV.
				-2.7	10.0
1	9	6	1		
1	25	36	1		
1	41	36	1		
1	57	64	1		
1	83	86	1		
1	96	93	1		
1	119	114	1		
1	130	132	1		
1	142	142	1		
1	154	140	1		
1	165	172	1		
1	177	176	1		
1	188	171	1		
1	213	216	1		
1	226	232	1		
1	238	234	1		
1	250	225	1		
1	262	261	1		
1	274	262	1		
1	281	274	1		
1	287	274	1		
1	299	308	1		
1	305	301	1		
1	311	307	1		
1	323	323	1		
1	329	339	1		
1	335	323	1		
1	347	347	1		
1	358	359	1		
				1.1	5.7
2	4	2	2		
2	48	44	2		
2	70	85	2		
2	101	95	2		
2	113	123	2		
2	147	162	2		
2	171	177	2		
2	200	200	2		
2	220	221	2		
2	256	249	2		
2	293	294	2		
2	353	358	2		
				1.1	5.7
3	NO SHIPMENT PLANNED				
				4.1	10.5
4	15	7	2		
4	62	55	2		
4	76	61	2		
4	107	121	2		
4	125	130	2		
4	159	155	2		

4	182	191	2		
4	207	218	2		
4	232	235	2		
4	268	279	2		
4	317	331	2		
				-2.2	15.8
5	31	17	2		
5	91	78	2		
5	136	144	2		
5	199	191	2		
5	244	240	2		
5	341	342	2		

TOTAL NUMBER OF DELIVERIES PLANNED 58

VESSEL DETAILS

CATEGORY	COAL CARRIED	DEMURRAGE RATE (US$/HOUR)	DESPATCH RATE (US$/HOUR)	CONTRACT NO. OF HOURS TO UNLOAD
1	52000	313.0	156.0	95
2	65000	313.0	156.0	116

NO. OF HOURS TO TRAVEL FROM LOCAL WATERS TO TYPHOON SHELTER	3
NO. OF HOURS TO TRAVEL FROM LOCAL WATERS TO JETTY	2
NO. OF HOURS TO BERTH AND TIE UP VESSEL	1

UNLOADER DETAILS

CREAM UNLOADING RATE OF UNLOADER NO. 1	750	TONNES/HOUR
CREAM UNLOADING RATE OF UNLOADER NO. 2	750	TONNES/HOUR
CREAM UNLOADING RATE OF UNLOADER NO. 3	0	TONNES/HOUR
MEAN TIME TO FAILURE OF UNLOADER NO. 1	142	RUNNING HOURS
MEAN TIME TO FAILURE OF UNLOADER NO. 2	138	RUNNING HOURS
MEAN TIME TO FAILURE OF UNLOADER NO. 3	300	RUNNING HOURS
STD.DEV. OF MTTF FOR UNLOADER NO. 1	42	
STD.DEV. OF MTTF FOR UNLOADER NO. 2	52	
STD.DEV. OF MTTF FOR UNLOADER NO. 3	100	
MEAN TIME TO REPAIR OF UNLOADER NO. 1	10	WORKING HOURS
MEAN TIME TO REPAIR OF UNLOADER NO. 2	10	WORKING HOURS
MEAN TIME TO REPAIR OF UNLOADER NO. 3	10	WORKING HOURS
STD.DEV OF MTTR FOR UNLOADER NO. 1	3	
STD.DEV OF MTTR FOR UNLOADER NO. 2	3	
STD.DEV OF MTTR FOR UNLOADER NO. 3	3	

OTHER INFORMATION

PLANNED COAL CONSUMPTION	3393000	TONNES
ACTUAL COAL CONSUMPTION	3398876	TONNES
INITIAL COAL STOCK LEVEL	200000	TONNES

DAY NO.	ARRIVALS	TYPHOON SIGNAL	UNLOADER OUTAGE 1	2	3	BERTH OCCUPANCY		MAXIMUN QUEUE	COAL UNLOADED	COAL CONSUMPTION	STOCK LEVEL
1									0.0	7634.6	192365.4
2	1					1			0.0	7981.0	184484.4
3						1			19500.0	7994.6	195989.8
4						1			25200.0	7326.1	213863.7
5			7			1			12750.0	7802.6	218811.0
6	2		1			1	2	1	7550.0	7198.8	219162.2
7	3			6			2	1	20700.0	5743.8	234118.5
8							2	1	21150.0	6721.1	248547.4
9						3	2	1	10150.0	7629.3	251068.1
10						3			24750.0	7631.0	268187.1
11						3			23400.0	8018.4	283568.7
12						3			14400.0	7387.3	290581.3
13						3			2450.0	7151.2	285880.2
14									0.0	5705.7	280174.4
15									0.0	7620.1	272554.4
16									0.0	7521.1	265033.2
17	4					4			0.0	7941.8	257091.5
18						4			19500.0	7483.7	269107.8
19						4			25200.0	6930.1	287377.7
20			14			4			10650.0	7151.2	290876.5
21						4			9650.0	5705.7	294820.8
22									0.0	7669.0	287151.8
23									0.0	6942.8	280209.0
24									0.0	8079.1	272130.0
25									0.0	7660.0	264470.0
26									0.0	7264.6	257205.3
27									0.0	7103.5	250101.8
28									0.0	5667.7	244434.2
29									0.0	7319.7	237114.5
30									0.0	7947.5	229167.0
31									0.0	7316.9	221850.1
32									0.0	7185.3	214664.8
33									0.0	6691.3	207973.4
34									0.0	7103.5	200870.0
35									0.0	5667.7	195202.3
36	5 6					5		1	18600.0	7493.3	206309.0
37						5		1	22050.0	7732.2	220626.8
38						5		1	11350.0	7449.0	224527.8
39						5	6	1	16500.0	7478.9	233548.9
40							6		22950.0	7265.0	249233.9
41							6		12550.0	7055.8	254728.1
42							6		0.0	5629.6	249098.4
43									0.0	6859.3	242239.1
44	7					7			10500.0	7703.8	245035.3
45						7			27900.0	7262.9	265672.4
46			9			7			14850.0	7285.7	273236.7
47			1			7			11750.0	7089.2	277897.5
48						7			0.0	6960.5	270937.0
49									0.0	5553.6	265383.5
50									0.0	8101.0	257282.5
51									0.0	7970.1	249312.4
52									0.0	7403.1	241909.3
53									0.0	7470.8	234438.6
54									0.0	7091.3	227347.3
55	8					8			15000.0	7055.8	235291.5
56				1		8			26025.0	5629.6	255696.9
57				10		8			13425.0	7119.6	261992.3

58				8			10550.0	7599.1	264943.3
59							0.0	7527.8	257415.4
60							0.0	7986.5	249428.9
61	9			9			20550.0	7823.6	262155.4
62		10		9			19950.0	7103.5	275001.9
63				9			16650.0	5667.7	285984.2
64	10			9	10	1	7850.0	8741.1	285093.1
65					10		23850.0	7318.9	301624.2
66			6		10		18000.0	7978.7	311645.5
67			6		10		10150.0	7715.6	314079.8
68					10		0.0	7782.9	306296.9
69							0.0	7294.2	299002.7
70							0.0	5819.8	293182.9
71							0.0	7660.4	285522.5
72							0.0	8065.3	277457.2
73							0.0	8222.7	269234.5
74							0.0	7821.6	261412.9
75							0.0	7983.1	253429.8
76							0.0	7389.5	246040.3
77							0.0	5895.9	240144.4
78	11			11			18000.0	8682.4	249462.0
79				11			25650.0	8319.2	266792.8
80				11			15300.0	8115.0	273977.7
81				11			6050.0	8658.3	271369.4
82							0.0	7887.3	263482.2
83							0.0	7723.3	255758.9
84							0.0	6162.2	249596.7
85	12			12			12000.0	8109.7	253487.0
86	13			12		1	27450.0	8340.0	272597.1
87			10	12		1	14100.0	8462.9	278234.2
88				12		1	11450.0	8692.2	280992.0
89				12	13	1	19650.0	8492.1	292149.9
90					13		21600.0	7866.3	305883.6
91					13		10750.0	6276.3	310357.3
92							0.0	8475.1	301882.3
93	14			14			15000.0	8976.2	307906.1
94				14			23850.0	8834.0	322922.1
95	15			14		1	13150.0	8084.1	327987.9
96			4	14	15	1	18000.0	8317.3	337670.6
97			10		15		20400.0	8009.3	350061.3
98					15		17550.0	6390.4	361220.9
99					15		9050.0	8051.0	362219.9
100							0.0	8649.9	353570.0
101							0.0	8024.2	345545.8
102							0.0	8841.9	336703.9
103							0.0	8684.5	328019.4
104							0.0	8104.7	319914.8
105							0.0	6466.5	313448.3
106							0.0	8960.2	304488.1
107							0.0	8396.8	296091.3
108							0.0	9125.6	286965.7
109							0.0	9144.1	277821.6
110							0.0	8975.1	268846.6
111							0.0	8295.4	260551.2
112							0.0	6618.6	253932.6
113							0.0	9660.1	244272.4
114	16			16			13500.0	9450.4	248322.0
115		7		16			22425.0	9013.7	261733.3
116				16			14850.0	9587.9	266995.4
117				16			1225.0	9569.9	258650.5

118								0.0	8724.4	249926.1
119								0.0	6961.0	242965.1
120								0.0	9585.5	233379.7
121	17				17			18000.0	9781.0	241598.6
122				11	17			19875.0	9641.2	251832.4
123	18			3	17		1	16875.0	10036.5	258671.0
124					17	18	1	10250.0	10013.0	258907.9
125						18		21600.0	9201.2	271306.8
126						18		24750.0	7341.4	288715.4
127						18		14400.0	10101.9	293013.5
128						18		4250.0	10453.4	286810.1
129								0.0	10467.7	276342.4
130	19							0.0	10222.4	266120.1
131					19			20550.0	10049.4	276620.7
132	20		4	8	19		1	18900.0	9582.6	285938.1
133			7		19		1	15225.0	7645.7	293517.5
134					19	20	1	10325.0	10039.8	293802.7
135						20		21750.0	10544.4	305008.2
136						20		20700.0	9943.2	315765.1
137						20		9550.0	10169.6	315145.4
138								0.0	10380.9	304764.5
139								0.0	9773.3	294991.2
140	21							0.0	7797.8	287193.4
141					21			18600.0	10166.8	295626.6
142	22				21		1	22050.0	10887.0	306789.6
143					21		1	11350.0	10690.8	307448.8
144					21	22	1	16500.0	10622.9	313325.9
145			2			22		22350.0	10524.6	325151.3
146	23					22	1	13150.0	9916.3	328385.1
147				3	23	22	1	18750.0	7911.9	339223.1
148				13	23			18600.0	10537.9	347285.3
149					23			18000.0	11337.8	353947.5
150					23			9650.0	10894.5	352703.1
151								0.0	10352.1	342351.0
152								0.0	10011.9	332339.1
153								0.0	10345.4	321993.7
154								0.0	8254.3	313739.4
155	24							0.0	11528.4	302211.1
156					24			19500.0	11146.1	310565.0
157					24			25200.0	11352.7	324412.3
158			9		24			12150.0	11039.2	325523.1
159					24			8150.0	10807.3	322865.7
160								0.0	10488.4	312377.3
161								0.0	8368.4	304009.0
162	25				25			20550.0	11217.1	313341.8
163					25			25200.0	11444.9	327097.0
164					25			14400.0	11158.0	330339.0
165					25			4850.0	11118.9	324070.1
166								0.0	10880.1	313190.0
167								0.0	10583.7	302606.3
168								0.0	8444.5	294161.8
169		T						0.0	11738.2	282423.6
170		T						0.0	11984.7	270438.9
171	26	T						0.0	11444.7	258994.2
172	27	T			26		1	15000.0	11645.4	262348.9
173			9		26		1	20925.0	11431.5	271842.4
174					26		1	14850.0	10679.1	276013.3
175					26	27	1	20875.0	8520.5	288367.8
176	28					27	1	21600.0	12662.2	297305.6
177	29				29	27	2	10750.0	11349.1	296706.5

178					12	29		1	18000.0	11573.3	303133.1
179				12		29		1	19350.0	11733.8	310749.3
180						29		1	18000.0	12016.6	316732.7
181						29	28	1	9650.0	10965.1	315417.6
182							28		21750.0	8748.8	328418.8
183							28		20700.0	11692.6	337426.1
184							28		9550.0	11417.9	335558.2
185									0.0	12538.6	323019.7
186									0.0	12068.6	310951.1
187									0.0	11102.3	299848.8
188									0.0	11203.5	288645.3
189									0.0	8939.0	279706.3
190									0.0	11883.5	267822.8
191	30	31				30		1	16500.0	12346.7	271976.0
192						30		1	26100.0	12368.1	285707.9
193				8		30		1	13350.0	12228.9	286828.9
194						30	31	1	9050.0	11760.8	284118.2
195							31		22650.0	11346.5	295421.6
196							31		24300.0	9053.1	310668.6
197							31		14400.0	12048.0	313020.5
198							31		3650.0	11737.7	304932.8
199									0.0	12059.1	292873.8
200	32					32			10500.0	12109.0	291264.7
201						32			27900.0	12503.0	306661.8
202				11		32			14475.0	11489.5	309647.2
203						32			12125.0	9167.2	312605.0
204						32			0.0	11830.6	300774.4
205									0.0	11995.8	288778.7
206									0.0	11767.9	277010.8
207									0.0	12225.7	264785.1
208									0.0	12006.0	252779.1
209									0.0	11346.5	241432.6
210									0.0	9053.1	232379.5
211									0.0	11787.2	220592.4
212									0.0	11948.7	208643.7
213									0.0	12306.4	196337.3
214									0.0	11708.0	184629.3
215									0.0	11687.4	172941.9
216	33					33			15000.0	11251.2	176690.7
217				14	12	33			12000.0	8977.0	179713.7
218	34					33		1	18450.0	11445.2	186718.5
219						33	34	1	15550.0	10924.0	191344.5
220							34		28350.0	12078.1	207616.4
221	35						34	1	18000.0	11888.4	213728.1
222				16			34	1	9600.0	12107.6	211220.5
223				1		35	34	1	20600.0	11155.8	220664.6
224					11	35			19425.0	8900.9	231188:7
225	36					35		1	17100.0	11647.3	236641.4
226						35	36	1	16925.0	12435.4	241131.0
227							36		27450.0	12740.5	255840.5
228							36		14400.0	12038.5	258202.1
229							36		1150.0	11514.7	247837.4
230									0.0	11108.1	236729.3
231									0.0	8862.9	227866.4
232	37					37			16500.0	11823.9	232542.5
233			I			37			6300.0	11928.3	226914.2
234	38		I			37		1	13650.0	11635.1	228929.1
235	39				11	37		2	11100.0	12368.8	227660.3
236				6	1	37	39	2	17950.0	12006.4	233604.0
237				5			39	1	24600.0	11108.1	247095.8

238							39	1	18000.0	8862.9	256233.0
239						38	39	1	8900.0	11650.0	253482.9
240	40					38		1	20700.0	11388.0	262794.9
241					10	38		1	18150.0	11773.6	269171.3
242				10		38		1	11400.0	11756.8	268814.4
243						38	40	1	21250.0	11746.5	278317.9
244							40		25200.0	10965.1	292552.8
245							40		14850.0	8748.8	298654.0
246							40		5450.0	11375.9	292728.1
247									0.0	11677.0	281051.1
248									0.0	11456.7	269594.4
249	41					41			0.0	11957.9	257636.6
250					4	41			22650.0	11927.9	268358.6
251					12	41			18900.0	10917.4	276341.2
252						41			16200.0	8710.7	283830.5
253				14		41			7250.0	11895.3	279185.2
254						41			0.0	11881.4	267303.8
255									0.0	11837.4	255466.5
256			T						0.0	11857.7	243608.8
257									0.0	11705.7	231903.1
258									0.0	10917.4	220985.7
259			T						0.0	8710.7	212275.0
260			T						0.0	11637.0	200638.0
261	42		T			42			15000.0	11927.2	203710.8
262	43					42		1	23850.0	10784.5	216776.2
263						42		1	13150.0	11700.0	218226.2
264						42	43	1	19650.0	10744.2	227132.0
265							43		21600.0	10917.4	237814.5
266							43		10750.0	8710.7	239853.8
267									0.0	11107.0	228746.8
268									0.0	11468.0	217278.9
269									0.0	11784.3	205494.6
270									0.0	11120.6	194374.0
271									0.0	11785.3	182588.7
272									0.0	10917.4	171671.3
273									0.0	8710.7	162960.5
274	44	45				44		1	16500.0	11214.8	168245.7
275						44		1	22950.0	10785.7	180410.0
276				10		44		1	11400.0	11874.4	179935.6
277						44	45	1	20800.0	11659.6	189076.1
278			T				45		14700.0	10969.5	192806.6
279	46		T				45	1	3900.0	10583.7	186122.9
280					7		45	1	12300.0	8444.5	189978.4
281						46	45	1	22000.0	10263.4	201715.0
282						46			25200.0	10264.1	216650.9
283						46			14400.0	10241.8	220809.1
284						46			4850.0	9890.9	215768.2
285									0.0	10397.6	205370.6
286									0.0	9677.9	195692.7
287									0.0	7721.7	187971.0
288									0.0	9898.9	178072.0
289									0.0	10432.1	167640.0
290									0.0	10057.7	157582.2
291			T						0.0	9426.2	148156.0
292			T						0.0	10194.7	137961.3
293			T						0.0	9296.5	128664.8
294	47					47			18000.0	7417.4	139247.4
295						47			25650.0	9341.6	155555.7
296						47			15300.0	9358.5	161497.2
297						47			6050.0	9218.3	158328.9

298									0.0	9698.1	148630.9
299									0.0	9537.2	139093.5
300									0.0	9058.1	130035.4
301	48								0.0	7227.2	122808.2
302			T			48			17550.0	9437.3	130920.9
303					2	48			21900.0	9137.0	143683.9
304					5	48			12550.0	9378.6	146855.3
305						48			0.0	9592.9	137262.3
306									0.0	8986.1	128276.2
307	49					49			19650.0	8676.7	139249.5
308	50			10	10	49		1	14700.0	6922.9	147026.5
309					2	49		1	14700.0	9173.8	152552.7
310						49	50	1	22600.0	9742.3	165410.4
311							50		21600.0	8880.7	178129.7
312							50		10750.0	9206.2	179673.5
313									0.0	8996.6	170676.9
314									0.0	8533.7	162143.2
315									0.0	6808.8	155334.4
316									0.0	8335.0	146999.4
317									0.0	8682.6	138316.7
318									0.0	8496.0	129820.7
319									0.0	8752.3	121068.4
320									0.0	8775.2	112293.2
321									0.0	8390.7	103902.5
322									0.0	6694.7	97207.8
323	51	52						1	0.0	8877.0	88330.7
324						51		1	19650.0	8350.7	99630.0
325						51		1	21600.0	9575.6	111654.4
326						51	52	1	10750.0	8402.9	114001.5
327					5		52		17850.0	8943.9	122907.6
328					5		52		21225.0	8247.7	135885.0
329							52		12925.0	6580.6	142229.4
330							52		0.0	8431.3	133798.0
331	53								0.0	9126.5	124671.5
332						53			16500.0	8144.1	133027.4
333						53			26100.0	8747.5	150379.9
334						53			15750.0	8679.5	157450.4
335				14		53			6650.0	8152.3	155948.1
336						53			0.0	6504.5	149443.6
337									0.0	8861.8	140581.8
338									0.0	8779.5	131802.3
339	54								0.0	8138.9	123663.3
340						54			19650.0	8283.0	135030.3
341						54			21600.0	8547.9	148082.4
342	55					54	55	1	10750.0	8057.0	150775.5
343							55		20550.0	6428.4	164897.0
344				12	11		55		13125.0	8056.7	169965.4
345							55		19800.0	8607.2	181158.1
346							55		11525.0	8455.7	184227.4
347	56					56	55		16500.0	9035.8	191691.6
348						56			22950.0	7978.4	206663.2
349						56			12550.0	7961.6	211251.6
350						56			0.0	6352.4	204899.2
351									0.0	8207.1	196692.1
352									0.0	8042.1	188650.0
353									0.0	8274.0	180376.1
354									0.0	8868.7	171507.4
355									0.0	8321.6	163185.8
356									0.0	7770.9	155414.8
357									0.0	6200.2	149214.6

358	57			57			19500.0	7834.8	160879.9
359	58			57		1	25200.0	8137.6	177942.3
360				57		1	14850.0	7596.6	185195.6
361		11	4	57	58	1	12950.0	8507.8	189637.8
362			5		58		25050.0	8378.7	206309.1
363					58		16200.0	7675.6	214833.5
364					58		3250.0	6124.1	211959.4
365							0.0	7834.8	204124.6

DEL. NO. /SOURCE/CAT.	DAY(HOUR) NOR	DAY(HOUR) COMMITTED	DAY(HOUR) RELEASED	DESPATCH (HRS)	DEMURRAGE (HRS)	WAITING TIME (HRS)	INTERRUPTIONS
1 / 2 / 2	2(12)	2(12)	6(15)	18	0	0	D#1 8 HRS
2 / 1 / 1	6(8)	6(16)	9(18)	0	0	8	D#2 6 HRS
3 / 4 / 2	8(8)	9(19)	13(7)	0	1	35	
4 / 5 / 2	17(14)	17(14)	21(18)	17	0	0	D#1 14 HRS
5 / 1 / 1	36(8)	36(8)	39(7)	0	0	0	
6 / 1 / 1	37(8)	39(8)	42(7)	0	0	48	
7 / 2 / 2	44(14)	44(14)	48(7)	37	0	0	D#1 10 HRS
8 / 4 / 2	55(8)	55(8)	58(19)	34	0	0	D#2 11 HRS
9 / 4 / 2	61(8)	61(8)	64(15)	38	0	0	D#1 10 HRS
10 / 1 / 1	64(8)	64(16)	69(7)	0	0	8	D#2 12 HRS
11 / 5 / 2	79(10)	79(10)	81(12)	43	0	0	
12 / 2 / 2	85(14)	85(14)	89(7)	38	0	0	D#2 10 HRS
13 / 1 / 1	86(13)	89(8)	91(19)	0	0	67	
14 / 1 / 1	93(12)	93(12)	96(7)	0	0	0	
15 / 2 / 2	95(8)	96(8)	99(17)	12	0	24	D#2 14 HRS
16 / 1 / 1	114(13)	114(13)	117(7)	0	0	0	D#1 7 HRS
17 / 4 / 2	121(10)	121(10)	124(19)	36	0	0	D#2 14 HRS
18 / 2 / 2	123(14)	124(20)	129(9)	2	0	39	
19 / 4 / 2	131(8)	131(8)	134(19)	34	0	0	D#1 11 HRS D#2 8 HRS
20 / 1 / 1	132(15)	134(20)	137(17)	0	0	53	
21 / 1 / 1	141(8)	141(8)	144(7)	0	0	0	
22 / 1 / 1	143(8)	144(8)	147(7)	0	0	24	D#1 2 HRS
23 / 5 / 2	146(8)	147(8)	150(18)	11	0	24	D#2 16 HRS
24 / 4 / 2	156(8)	156(8)	159(15)	38	0	0	D#1 9 HRS
25 / 2 / 2	162(8)	162(8)	165(10)	43	0	0	
26 / 1 / 1	172(12)	172(12)	175(7)	0	0	0	D#1 9 HRS T 17 HRS
27 / 1 / 1	173(8)	175(8)	177(19)	0	0	48	
28 / 1 / 1	176(8)	181(19)	184(17)	0	0	131	
29 / 2 / 2	177(8)	177(20)	181(18)	11	0	12	D#1 12 HRS D#2 12 HRS
30 / 4 / 2	191(11)	191(11)	194(17)	39	0	0	D#1 8 HRS
31 / 5 / 2	191(16)	194(18)	198(8)	0	43	74	
32 / 2 / 2	200(15)	200(15)	204(7)	38	0	0	D#1 11 HRS
33 / 1 / 1	216(12)	216(12)	219(12)	0	0	0	D#1 14 HRS D#2 12 HRS
34 / 4 / 2	219(8)	219(13)	223(7)	27	0	5	D#1 17 HRS
35 / 2 / 2	222(8)	223(8)	226(15)	14	0	24	D#2 11 HRS
36 / 1 / 1	225(8)	226(16)	229(7)	0	0	32	
37 / 1 / 1	232(8)	232(8)	236(9)	0	0	0	D#2 12 HRS T 29 HRS
38 / 1 / 1	234(12)	239(17)	243(7)	0	0	125	D#1 10 HRS D#2 10 HRS
39 / 4 / 2	235(14)	236(10)	239(16)	19	0	20	D#1 11 HRS
40 / 5 / 2	241(8)	243(8)	246(11)	0	6	48	
41 / 2 / 2	249(16)	249(16)	254(7)	16	0	0	D#1 14 HRS D#2 16 HRS
42 / 1 / 1	261(9)	261(9)	264(7)	0	0	0	
43 / 1 / 1	263(8)	264(8)	266(19)	0	0	24	
44 / 1 / 1	274(8)	274(8)	277(7)	0	0	0	D#1 10 HRS
45 / 1 / 1	274(13)	277(8)	281(7)	0	0	67	D#2 7 HRS T 29 HRS
46 / 4 / 2	280(8)	281(8)	284(10)	19	0	24	
47 / 2 / 2	294(10)	294(10)	297(12)	43	0	0	
48 / 1 / 1	302(9)	302(9)	305(7)	0	0	0	D#2 7 HRS T 8 HRS
49 / 1 / 1	307(8)	307(8)	310(7)	0	0	0	D#1 10 HRS D#2 12 HRS
50 / 1 / 1	309(8)	310(8)	312(19)	0	0	24	
51 / 1 / 1	324(8)	324(8)	326(19)	0	0	0	
52 / 1 / 1	324(8)	326(20)	330(7)	0	0	60	D#2 10 HRS
53 / 4 / 2	332(8)	332(8)	336(7)	33	0	0	D#1 14 HRS
54 / 1 / 1	340(8)	340(8)	342(19)	0	0	0	
55 / 5 / 2	342(8)	342(20)	347(7)	8	0	12	D#1 12 HRS D#2 11 HRS
56 / 1 / 1	347(10)	347(10)	350(7)	0	0	0	
57 / 2 / 2	358(9)	358(9)	361(13)	41	0	0	D#1 6 HRS

58 / 1 / 1 359(8) 361(14) 364(7) 0 0 54 D#1 5 HRS D#2 9 HRS

TOTAL COAL CONSUMED	3388876	TONNE
TOTAL COAL DOUBLE HANDLED	1542210	TONNE
TOTAL COAL UNLOADED	3393000	TONNE
BERTH OCCUPANCY	51.56393	%
TOTAL DEMURRAGE CHARGE	15650	US$
TOTAL DESPATCH VALUE	110604	US$
NET PAY OUT	-94954	US$
MAXIMUM QUEUE LENGTH	2	
AVERAGE WAITING TIME	19.05172	HRS/SHIP

NO. OF DAYS COAL STOCK WENT ABOVE 456000 TONNES	0	DAYS
NO. OF DAYS COAL STOCK WENT ABOVE 299000 TONNES	69	DAYS
NO. OF DAYS COAL STOCK FELL BELOW 200000 TONNES	94	DAYS
NO. OF DAYS COAL STOCK FELL BELOW 150000 TONNES	39	DAYS
NO. OF DAYS COAL STOCK FELL BELOW 100000 TONNES	3	DAYS
NO. OF DAYS COAL STOCK FELL BELOW 50000 TONNES	0	DAYS
NO. OF DAYS COAL STOCK OUT	0	DAYS

NO. OF HOURS UNLOADER NO. 1 DOWN FOR DEFECT MAINTENANCE 230
NO. OF HOURS UNLOADER NO. 2 DOWN FOR DEFECT MAINTENANCE 220
NO. OF HOURS UNLOADER NO. 3 DOWN FOR DEFECT MAINTENANCE 0
NO. OF TYPHOONS IN THE YEAR IS 8 AND TOTAL TYPHOON HOURS IS 229

Appendix 3 List of Variables

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INPUT VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
AMTTFA	MEAN TIME TO FAILURE, UNLOADER A
AMTTFC	MEAN TIME TO FAILURE, UNLOADER C
AMTTRA	MEAN TIME TO REPAIR, UNLOADER A
AMTTRB	MEAN TIME TO REPAIR, UNLOADER B
AMTTRC	MEAN TIME TO REPAIR, UNLOADER C
ATE(NVT)	TOTAL COAL CARRIED BY CATEGORY NVT VESSELS
CCSTD	COAL CONSUMPTION STD DEV FOR WEEK DAYS
CCTOT	TOTAL PLANNED COAL CONSUMPTION FOR THE YEAR
CSLI	INITIAL COAL STOCK LEVEL
CSSAT	COAL CONSUMPTION RATIO REDUCTION FOR SATURDAYS
CSSUN	COAL CONSUMPTION REDUCTION RATIO FOR SUNDAYS
DMM(NVT)	DEMURRAGE RATE FOR CATEGORY NVT VESSELS
DSS(NVT)	DESPATCH RATE FOR CATEGORY NVT VESSELS
FDEVA	STANDARD DEVIATION OF MTTF, UNLOADER A
FDEVB	STANDARD DEVIATION OF MTTF, UNLOADER B
FDEVC	STANDARD DEVIATION OF MTTF, UNLOADER C
ICHUL(NVT)	CONTRACT NO OF HOURS TO UNLOADER CATEGORY NVT SHIP
IMTTFB	MEAN TIME TO FAILURE, UNLOADER B
IPAD(NSN,ND)	PLANNED ARRIVAL DATES OF DEL ND FROM SOURCE NSN
ITBER	TIME TO TRAVEL FROM LOCAL WATERS TO JETTY
ITERATION	NO. OF ITERATION TO RUN
ITIDE(N,IH)	TIDE CONDITION AT DAY N, HOUR IH
IULA	CREAM UNLOADER RATE OF UNLOADER A
IULB	CREAM UNLOADING RATE OF UNLOADER B
IULC	CREAM UNLOADING RATE OF UNLOADER C
NCAT(NSN,ND)	CATEGORY OF DELIVERY ND FROM SOURCE NSN

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INPUT VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
ND(NSN)	NUMBER OF DELIVERIES FROM SOURCE NSN
NHBTH	TIME TO BERTH AND TIE UP VESSEL
NHRET	TIME TO TRAVEL FROM LOCAL WATERS TO SHELTER
NS	NUMBER OF SOURCES OF COAL
NVTOT	NUMBER OF CATEGORY OF VESSELS USED
PAETA(NSN)	MEAN DELAY FROM SOURCE NSN
PASD(NSN)	STD DEV OF DELAYS FROM SOURCE NSN
REPDEVA	STANDARD DEVIATION OF MTTR, UNLOADER A
REPDEVB	STANDARD DEVIATION OF MTTR, UNLOADER B
REPDEVC	STANDARD DEVIATION OF MTTR, UNLOADER C

DERIVED VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
?$??$ LEN?	DUMMY VARIABLES USED IN PRINTOUT FORMATS
ADOWN	UNLOADER A DOWN TIME IN THE DAY
ARRQUEUE	SUBROUTINE FOR QUEUE MANAGEMENT
ASSIGNNOR	SUBROUTINE FOR ASSIGNING NOR DAY AND TIME
BDOWN	UNLOADER B DOWN TIME IN THE DAY
BERTHOCC	SUBROUTINE FOR CALCULATING BERTH OCCUPANCY
BREAKDOWN	SUBROUTINE BREAKDOWN
BREAKDOWN	SUBROUTINE FOR HANDLING UNLAODER DEFECTS
CC(N)	COAL CONSUMED ON DAY N
CCT	TOTAL AMOUNT OF COAL CONSUMED
CCU	TOTAL COAL UNLOADED FOR THE SHIP
CDH	AMOUNT OF COAL DOUBLE HANDLED
CDOWN	UNLOADER C DOWN TIME IN THE DAY
CS(N)	COAL STOCK LEVEL ON DAY N
CS1 - CS6	COAL STOCK LEVEL REGISTERS IN DAYS
CU(N)	COAL UNLOADED ON DAY N
CUT	TOTAL AMOUNT OF COAL UNLOADED
DEFECTA(NN)	DEFECT HR. OF UNLOADER 1 DURING SHIPMENT NN
DEFECTB(NN)	DEFECT HR. OF UNLOADER 2 DURING SHIPMENT NN
DEFECTC(NN)	DEFECT HR. OF UNLOADER 3 DURING SHIPMENT NN
DM(NN)	DEMURRAGE HOURS OF DELIVERY NN
DMD	NET PAID OUT (TOTAL DEMURRAGE - TOTAL DESPATCH)
DMT	TOTAL DEMURRAGE PAYABLE
DOUTPUT	SUBROUTINE DOUTPUT
DOUTPUT	SUBROUTINE TO PRODUCE OUTPUT
DS(NN)	DESPATCH HOURS OF DELIVERY NN

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DERIVED VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
DSS	TOTAL DESPATCH RECEIVABLE
DUR(N)	DURATION OF TYPHOON NO. N
GAUSS	SUBPROGRAM FOR GENERATING NORMAL DIST. SAMPLES
IAAA	HOURS DIFFERENCE BETWEEN ACTUAL AND CONTRACT RATE
IAOUT(N,IH)	UNLOADER A OUTAGE AT DAY N HOUR IH
IARR(I)	SEQUENCE NO OF SHIP ARRIVAL IN THE HOUR
IB	DUMMY VALUE FOR TIME USED TO TRAVEL TO JETTY
IBN, IBH	DAY AND HOUR REPAIR WORK COMPLETED
IBOC,BOC	BERTH OCCUPANCY HOURS AND PERCENTAGE
IBOUT(N,IH)	UNLOADER B OUTAGE AT DAY N HOUR IH
ICOUT(N,IH)	UNLOADER C OUTAGE AT DAY N, HOUR IH
IH	HOUR NO. GENERAL
IHDUM	HOUR NO .QUEUING PROGRAM
IHNXT	HOUR NO. OF THE NEXT HOUR IN THE QUEUING PROGRAM
IK	DUMMY VALUE FOR TIME USE TO GO TO TYPHOON SHELTER
INITUNLOADER	SUBROUTINE TO INITIALIZE UNLOADER VARIABLES
INSPECT	SUBROUTINE FOR EQUIPMENT INSPECTION AFTER UNLOAD
IRUNA	RUNNING HOURS OF UNLOADER A
IRUNA, B, C	RUNNING HOURS OF UNLOADER 1,2 & 3 RESPECTIVELY.
IRUNB	RUNNING HOURS OF UNLOADER B
IRUNC	RUNNING HOURS OF UNLOADER C
ISD	FLAG FOR PRINT POSITION OF BERTH OCCUPANCY
ISOURCE(NN)	SOURCE OF DELIVERY NO. NN
ISQ	SOURCE NO. OF SHIP IN QUEUE
IT(N,IH)	TYPHOON SIGNAL, DAY N, HOUR IH
IULAA,IULAAA	UNLOADER A CAPACITY AVAILABLE IN THE HOUR

DERIVED VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
IULBB,IULBBB	UNLOADER B CAPACITY AVAILABLE IN THE HOUR
IULCC,IULCCC	UNLOADER C CAPACITY AVAILABLE IN THE HOUR
IULDR	TOTAL UNLOADING CAPACITY AVAILABLE IN THE HOUR
IWAIT(NN)	WAITING TIME FOR SHIPMENT NN
L	TOTAL TYPHOON HOURS IN A YEAR
MM,MMM	DUMMY VALUES USED FOR CALCULATING BREAKDOWN HOURS
N	DAY NO. GENERAL
NAAS(N,IH)	ACTUAL ARRIVAL SCHEDULE
NB(N,IH)	VESSEL NO. BERTHED ON DAY N HOUR IH
NB1,NB2	PRINT POSITION FOR BERTH OCCUPANCY
ND1 ND2 ND3 ND4	DUMMY VALUES FOR START/FINISH OF A PERIOD
NDB(NN)	DAY NO. SHIP NN CLEARED FOR BERTHING
NDC(NN)	DAY NO OF DELIVERY NN COMMITED
NDD(N)	DAY NO TYPHOON NO. N STARTS
NDUM	DAY NO. QUEUING PROGRAM
NDV(NN)	DAY NO. DELIVERY NN RELEASED
NDVV(NN)	DAY NO. DELIVERY NN COMPLETED UNLOADING
NEGEXP	SUBPROGRAM FOR NEGATIVE EXPONENTIAL SAMPLING
NHB(NN)	HOUR NO. SHIP NN CLEARED FOR BERTHING
NHC(NN)	HOUR NO. DELIVERY NN COMMITTED
NHV(NN)	HOUR NO. DELIVERY NN RELEASED
NHVV(NN)	HOUR NO. DELIVERY NN COMPLETED UNLOADING
NN	DELIVERY NO.
NNN, IHHH	DAY AND HOUR NO. SHIP EXPECTED TO BERTH
NNTOT	TOTAL NO. OF PLANNED DELIVERIES
NNXT	DAY NO OF THE NEXT HOUR IN THE QUEUING PROGRAM

DERIVED VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
NOR	NOTICE OF READINESS
NORH(NN)	HOUR NO. DELIVERY NN TENDERED NOR
NORN(NN)	DAY NO. DELIVERY NN TENDERED NOR
NP	DAY NO OF PREVIOUS DAY IN CALCULATING COAL STCK
NQ1(N,IH)	1ST POSITION IN QUEUE, DAY N, HOUR IH
NQ2(N,IH)	2ND POSITION IN QUEUE, DAY N, HOUR IH
NQ3(N,IH)	3RD POSITION IN QUEUE, DAY N, HOUR IH
NQ4(N,IH)	4TH POSITION IN QUEUE, DAY N, HOUR IH
NQ5(N,IH)	5TH POSITION IN QUEUE, DAY N, HOUR IH
NQ6(N,IH)	6TH POSITION IN THE QUEUE, DAY N, HOUR IH
NQMAX	MAXIMUM QUEUE LENGTH
NQQQ	DUMMY VALUE FOR FINDING NQMAX
NSHIP(N,IH)	DAY N HOUR IH BERTH DESIGNATED TO SHIP NN
NTU	NO OF HOURS INTO TIE UP TIME ,
NUH	NO OF HOURS UNLOADING
NXX	NO. OF TYPHOONS GENERATED
QUEUETIME	SUBROUTINE FOR ASSIGNING TIMES AFTER A SHIPMENT
RUNN	NO. OF ITERATION LOGGED
SUMADOWN	TOTAL DOWN TIME OF UNLOADER 1
SUMBDOWN	TOTAL DOWN TIME OF UNLOADER 2
SUMCDOWN	TOTAL DOWN TIME OF UNLAODER 3
SUMWAIT	TOTAL WAITING TIME IN A YEAR
TTFA	TIME TO FAILURE, UNLOADER A
TTFB	TIME TO FAILURE, UNLOADER B
TTFC	TIME TO FAILURE, UNLOADER C
TTRA	TIME TO REPAIR, UNLOADER A

DERIVED VARIABLES

MARINE TERMINAL SIMULATION
LIST OF VARIABLES

VARIABLE	VARIABLE DESCRIPTION
TTRB	TIME TO REPAIR, UNLOADER B
TTRC	TIME TO REPAIR, UNLOADER C
TY$	FLAG FOR TYPHOON
TYPHOON(NN)	TYPHOON HR. DURING SHIPMENT NN
UNLOAD	SUBROUTINE UNLOAD
UNLOAD	SUBROUTINE FOR UNLOADING
X$	INPUT TO CONFIRM PRINTER READY

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